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Forthcoming Events.

Institute of British Foundrymen.

FEBRUARY 6.

Scottish Branch:—Ordinary meeting at Glasgow. "A Glimpse into a Non-Ferrous Foundry," Paper by J. D. Frame.

Wales and Monmouth Branch:—Ordinary meeting at Newport. "Non-Ferrous Alloys," Paper by Wesley Lambert.

FEBRUARY 9.

Lancashire Branch (Burnley Section):—Ordinary meeting at Burnley. "A Talk on Foundry Work," Paper by H. Shankleton.

FEBRUARY 11.

London Branch:—Ordinary meeting in London. "The Necessity for Standardisation in Modern Foundry Practice," Paper by M. J. Cooper.

FEBRUARY 13.

Newcastle-on-Tyne Branch:—Ordinary meeting at Newcastle-on-Tyne. "The Cupola," Paper by L. V. Banks.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Permanent Mould Aluminium Alloy Casting.

We start this issue with an important series of articles by Dr. Robert J. Anderson on "Permanent Mould-Cast Aluminium Alloy Castings." Dr. Anderson is probably America's foremost metallurgist specialising in aluminium alloys, and is known to the British foundry world on account of his having contributed the exchange Paper to the Institute of British Foundrymen on behalf of the American Foundrymen's Association, and, of course, for his well-known treatise on the metallurgy of aluminium.

The perusal of this series has brought strongly to our notice the value of the American market to the non-ferrous founder. It is so large that, providing the product is suitable, quantity production can be established at the inception. Probably it has no larger capacity than the British domestic, Dominion and general overseas markets wherein we habitually compete, but, in spite of modern means of communication, there is an important time-lag before these markets can be reached. This involves that the British manufacturer must develop much more slowly, a condition which is often sufficient to preclude manufacturing on the best quantity-production lines.

Under American conditions Dr. Anderson insists that where cores number up to seven pieces, where the quantity required is sufficient, where sections are not too thin, then the permanent-mould process is the most economical foundry proposition for light alloy castings. Additionally, the permanent-mould process ensures sounder castings than either die- or sand-cast similar articles, providing, of course, the mould is of proper construction.

Several firms in Great Britain have achieved considerable success with this process, and automobile crank case covers are regularly made by this process. Aluminium brass, an alloy which is prone to be troublesome when sand cast, is quite "docile" under permanent-mould casting conditions.

A number of foundries would be only too happy to utilise this process, but the cost of the mould constitutes an important deterrent. The steel cores, according to Dr. Anderson, have a life of 20,000 pours, whilst the cast-iron mould itself is for all practical purposes permanent.

It is obvious that the construction of these moulds requires the closest possible co-operation between the designer, steel metallurgist (for the provision of suitable alloy steel for the cores), the foundry foreman (for the running of the job in order to secure sound castings) and the iron-foundry metallurgist (for the provision of cast iron of suitable thickness and composition).

It has been said that foundrymen can place blowholes where they like in a casting, and it is just this very knowledge which makes their co-operation invaluable when the design of a mould is being considered. On theoretical grounds the permanent mould should be made as thin as practical conditions will allow, so as to reduce the temperature lag between the central position and the face, because it is the difference in the temperature of the two positions which originates cracking in a manner somewhat analogous to the spalling of a too-quickly heated furnace wall.

The old-fashioned craftsman will no doubt regard this and allied processes, which eliminate patterns and sand, as still another method of eliminating craftsmanship. Like most other quantity-production processes, it does eliminate the quantity of skilled men required, but demands still more quality and skill from those associated in a skilled capacity with newer conditions.

Sheffield Foundrymen's Annual Dinner.

Last Friday, the members of the Sheffield Branch of the Institute of British Foundrymen and their friends spent a happy time, when the Branch annual dinner was held, under the chairmanship of Engineer Lieutenant-Commander L. Jackson. The toast of "The City and Commerce of Sheffield" was proposed by the Mayor of Chesterfield (Alderman H. Cropper) and replied to by the Lord Mayor of Sheffield (Alderman J. Benson) and the Master Cutler (Mr. T. R. Ellin), the latter pleading not only for co-operation between employer and employee, but also between competitors. He feared the Safeguarding of Industries Bill was often too long delayed in putting into operation, which allowed of the accumulation of foreign stocks in British warehouses.

The toast of "The Guests" was given by Dr. Desch, who commented upon the multiplicity of technical societies and pleaded for the holding of more conjoint meetings, which made for better attendances and more interesting discussions. Mr. Albert Senior replied. Major-General Sir Frederick Sykes, M.P., proposing the toast of "The Institute," complimented the Society on the work it was doing and pleaded for more concentration on research work.

Mr. John Cameron, J.P., the President, in reply, made a special appeal to all foundry owners either to take an active part in the work of the Institute or afford facilities for their staff to replace them. They would find that great benefits were to be derived.

Mr. Yerbury, of the local electricity supply department, proposed the health of the Chairman, to which Commander Jackson replied, using the occasion as an opportunity for thanking his officers for the support they had accorded him.

Research in Cast Iron.

Last Friday, before the Manchester Association of Engineers, Mr. J. G. Pearce, the Director of the B.C.I.R.A., gave an interesting lecture entitled "The Value of Research in the Production of Castings." In opening, Mr. Pearce cited the case of a series of small castings exhibiting small hard spots which caused trouble on machining. These were due to phosphide eutectic, which can under some conditions be glass hard. The malleable industry was used as a second example. A batch of defective castings exhibited a higher total carbon and sulphur content than the pig. Increasing quantities of scrap had been used until the danger line had been crossed.

A third case related to a plough for a cement mill containing 3 per cent. carbon and 1.75 per cent. silicon, which "spalled" in service. The reason assigned for this was the chilling effect of the green-sand mould which had set up a crystal structure different from that in the interior.

A corner of sand acting as a heat retainer and maintaining the iron in a liquid condition for a longer period than the rest of the mould was emphasised, together with the defects it introduces. The lecturer, after establishing a relationship between the great German research establishments and recent remarkable developments in cast iron, outlined some of the latter. He first dealt with the desulphurising process using briquettes made of alkalis and alkaline earths and later explained the underlying principles of Emmel, hot mould (Perlit) Schuz and Nomag irons.

Death of Mr. T. W. Ward.

We regret to learn of the death which took place last Tuesday of Mr. T. W. Ward, of Sheffield, who was one of the pioneers of the modern shipbreaking industry.

Inter-University Metallurgical Conference.

An important gathering of metallurgical students, representative of the whole body of university-trained metallurgists in the United Kingdom, will take place in the Edgbaston buildings of the Birmingham University on February 19 and 20 next, commencing at 10 a.m. and 9.30 a.m. on each day respectively. Representatives of local and other works are cordially invited to attend and speak. The object of the Conference this year is the promotion of a fuller understanding and a greater degree of mutual sympathy and co-operation between works and University departments. For this purpose the subject for discussion will be "The Position of the Metallurgical Student in Industry." The findings of the Conference will be communicated as fully as possible to the technical press, and correspondence is invited, through these columns, from heads and works managers, indicative of their attitude towards the subject. Delegates will pay a visit to the British Industries Fair and will be the guests at a dinner of the Birmingham University Metallurgical Society on Friday, February 19. Further information can be obtained on application to the Hon. Sec., Metallurgical Society, University of Birmingham.

Catalogues Received.

Chain Drives.—Messrs. Hans Renolds, Limited, of Didsbury, Manchester, in their latest 48-page pamphlet, entitled "Standard Chain Drives," have provided a useful catalogue which should materially assist engineers to select suitable drives without the delay of obtaining price quotations, and aid users to erect and maintain in the best possible way.

Melting Furnaces.—British Reverbatory Furnaces, Limited, of 82, Victoria Street, London, S.W.1, are to be congratulated on their latest catalogue. It is jacketted in black, with the firm's name brought out as a red medallion. It contains 28 pages, and the method sought has been to illustrate a large number of installations, interspersing it with technical data.

Temperature Chart for Processes in Ferrous Metals.

Mr. Mohan Kirtane has prepared a very interesting temperature chart covering the whole field of ferrous metallurgy from the melting point of refractories to the heat treatment of the finished product. The amount of data which has been put into one diagram is almost astounding. They can be obtained from Dacres Rabjohns, Ltd., of 14, Victoria Street, Westminster, S.W.1, at the price of 3s. per copy.

British Metallurgist for Chile.

Mr. A. Marks, F.I.C., who was until recently chief metallurgist to Messrs. A. Harper, Sons and Bean, Limited, of Dudley, is next week leaving for Chile to take up an appointment with British Nitrates, Limited. Birmingham and district foundrymen are offering him a farewell dinner to-morrow night.

In our issue of January 28, 1926, it was incorrectly stated that Major Rhydderch was formerly head of the Research Department of Hadfields, Limited. As is well known Major Rhydderch specialised in moulding sand research when engaged with that company.

THE DENBIGH ENGINEERING COMPANY, LIMITED, of Tipton, S. Staffs., have just completed arrangements with a well-known firm for the purpose of demonstrating their hand jolt ram moulding machines in a foundry in Manchester for a fortnight, commencing February 15, 1926. The manufacturers will be pleased to arrange demonstrations upon hearing from firms who are interested.

Liquid Shrinkage in Grey Iron.*

By J. Longden (Glasgow).

Existing Theories.

Continental foundrymen, notably Ronceray, Brunelli and Leonard, had given a good deal of thought to the question whether the cavities and porosities found in grey iron are to be attributed mainly to the action or presence of gases, or to a simple increase in density of the metal on crystallising. They leaned to the view that the chief cause was gas, either "entrained" in the act of pouring, or given off from the mould or cores. They further suggested that important changes, about which little was known, took place in cast iron, in passing from a high temperature to solidification. In their view the liquid grey iron expanded with falling temperature and if a mould was soundly rammed and no risers were provided such expansion helped to procure soundness in the cast-

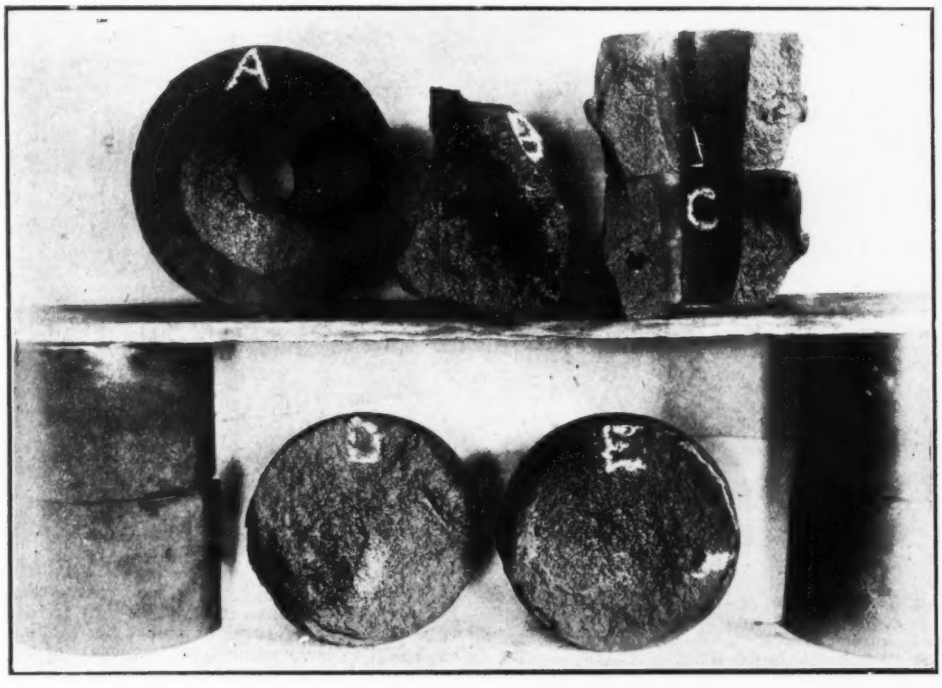


FIG. 1.—SAMPLE CASTINGS EXHIBITING DEFECTS.

ing. Fletcher, in this country, had long held somewhat similar views as to the importance of the question of gas influences, though his conclusions were not quite in line with those just referred to.

Some important principles of a practical character were dependent upon the answer to this question of the cause of cavities in grey iron. The technique of the foundry had been slowly built up by generations of foundrymen who believed that cast iron shrinks on solidifying. Without losing sight of the importance of venting, experience taught them the need for feeding, by rod or head, or for some alternative or supplementary method. If the "gas school" were correct attention must be directed mainly to questions as to melting conditions, venting, and pouring, and as to mould materials.

C, Fig. 1, shows the broken boss of a pinion with cast teeth, weighing 52 lb. The boss had $1\frac{1}{4}$ in. of metal all round the core, and was joined to the rim by a solid web, $\frac{7}{16}$ in. thick. The casting was poured through a pencil runner placed on the rim; the metal was of the following composition:—Silicon, 2.40; total carbon, 3.40; manganese, 0.45; phosphorus, 1.30; and sulphur, 0.10 per cent. Was the cavity shown due to gas which had been entrained in the act of pouring, or to gases from the mould or core which had not found a way out?

With a properly-made runner basin there appeared to be no reason why air should be entrained. If a basin of proper size was used and kept full whilst casting was going on, the runner was as well sealed as it would be if a filter core were used. In this case a pencil runner was used, so presumably no air could have been entrained. Unless dull iron was used there was no reason why air carried down with the metal should not at once free itself on entering the mould and pass out through the interstices of the sand of the mould or the riser, together with the air which filled the mould at the commencement of casting. The relative difference in gravity of cast iron and the gases concerned was so great as to make it extremely difficult for the latter, if free, to stay below the surface of the metal. In hot metal (leaving out of consideration for the moment the question of dissolved gases) gas must rise to the top; if it could not escape it would be found later at the top or lodged under some projection. Such bubbles could always be related to some unsuitable mould condition, and "blowing" would have taken place at the runner or riser. Therefore it could not be admitted that entrainment of air might be responsible for the cavity in the boss.

Is gas emitted from the core or mould at a later stage, when it cannot rise to the top owing to the partial solidification of the metal? The author rejects this suggestion. It could not be imagined where, at that stage, the metal could have gone to which occupied the space supposed to have been taken up by the gas. A conclusive point was that the cavity was penetrated by crystal growths. Crystallisation could not proceed in gas, only in molten metal; therefore the space where the cavity was must have been previously filled with liquid which had drained away leaving the stark skeleton outstanding.

Leonard Effect.

In respect of examples A and C, Fig. 1, the question might be discussed whether the defects were due to what had been called the "Leonard effect." In other words had gas lodged

* A Paper read before the Lancashire Branch and the Paisley Section of the Institute of British Foundrymen.

in the location of the defect, because such a location presented the line of least resistance. Where a core was insufficiently dried or vented, or the mould was insufficiently vented, it might, sometimes, whilst the metal in the runner or riser was fluid, be easier for the gases to force their way through the liquid metal than back through the core or mould. But here, again, the cavities shown had evidently been formed when solidification was rather advanced. If a bubble of gas had been trapped in that central position whilst the metal was fluid, no crystals could grow in the rounded space occupied by the gas, and the cavity would have the smooth, round form which was always associated with simple gas cavities. One could not conceive of gas forcing its way from mould or cores into a section in which solidification was so far advanced that a skeleton crystal growth had been formed. At such a stage runners and risers were frozen, and metal could not be squeezed out from the casting. How, then, could gas force its way into partly-solidified metal? Probably gas could not cause cavity or porosity in that way.

On the face of it, the idea behind what had been called the "Leonard effect" was very plausible. A cavity was attributed to the emission of gas from some local piece of the mould or core. Very often such defects were found near to parts of the mould which were difficult to vent properly, but that was only coincidence. The important fact was that such parts lost heat relatively slowly, and when a portion of a mould or core was badly vented, a part of the casting was thereby kept hotter than it otherwise would be. A good vent was also a good conductor of heat—that of hot gases from the mould face. The resulting hot spot might serve as a feeder for surrounding parts of the casting.

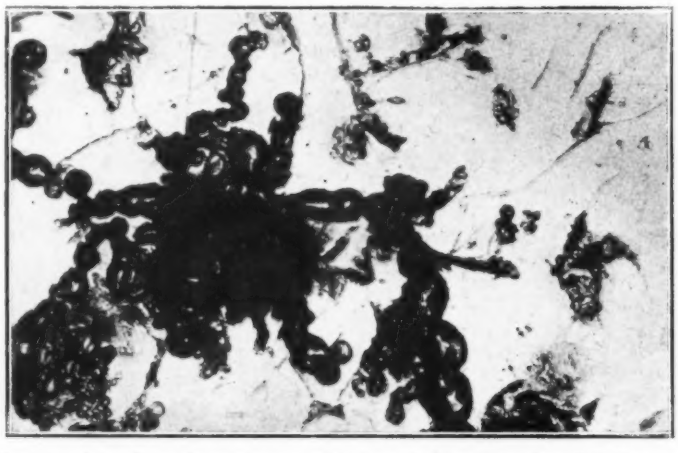


FIG. 2.—OPEN-SAND-CAST BAR × 350 DIAS. EXHIBITING GAS BUBBLES.

Many foundrymen expressed themselves as doubtful whether the appearance of a cavity could be said to show whether the cause was gas or not. There were difficult marginal cases, but generally speaking the difference was very marked, in minute cavities as well as in large ones. This statement is confirmed by a microphotograph (Fig. 2) of an open-sand-cast bar, 1 in. × 1 in., the last of four which were poured out of one shank of metal, each bar representing a stage in the process for the elimination of sulphur. The fourth was cast when the metal was rapidly nearing the pasty stage. It was fluid enough to allow the gas bubbles to distend in spherical form, but the fluidity was exhausted just in time to hold the bubbles at or near their points of generation. The important thing to notice is the bright, rounded appearance of these microscopical bubbles, which were photographed at a magnification of 350 diameters. The agent was definitely gas, as the appearance showed. No dendrites were seen penetrating them.

Gas Content of Metals.

Allerman and Darlington had stated that ferrous alloys might occlude large quantities of gases, in some cases equal to 200 times the volume of the metal; and that hydrogen was the most readily set free, carbon monoxide next, whilst nitrogen was held most tenaciously. Very little information was available as to the amount of gases soluble in cast iron at any given temperature, though the fact was well established that cast iron, when molten, did contain large quantities of gas. It was equally well established that large quantities of gas were kept in solution after solidification was complete. Cast iron, however, on passing from the ore in the blast furnace to the ladle under the cupola spout, had reached whatever degree of saturation by gas represented equilibrium; and it did not seem reasonable to suppose that such cast iron could take up into solution further quantities of gas in the mould. The conclusion, therefore, was that gases generated in the mould must pass away as bubbles or be trapped in the same condition. This statement might require to be modified, in line with the views expressed by Fletcher, namely, that mould conditions might be responsible for the presence of iron oxide in the metal whilst liquid in the mould, and this, reacting with carbon, might produce CO, which then became instrumental in producing cavities. Hadfield told them that free oxygen had never been extracted from either solid or molten steel. Therefore, if oxygen was present it must be as oxide. J. E. Johnson was said to have found 0.065 per cent. of oxygen in a cast iron, but he obtained his results by bessemerising a low-silicon iron from a cool-running furnace. Relatively little British foundry iron to-day came from such furnaces.

Comparison with Steel Conversion.

It was well established, however, that silicon, carbon and manganese were strong deoxidising agents, and small quantities added to molten steel were found to prevent or reduce the tendency for gases to come out of solution on solidification of the metal, and thus to prevent blowholes. That the reactions between iron oxides and silicon, carbon and manganese were very rapid might be gauged from the fact that, in a 10-ton acid Bessemer blow, 8½ cwts. of these elements were oxidised out in 9 minutes. In the cupola the great bulk of the metal in the well was in contact with incandescent coke for as long a period or longer. Circumstances, therefore, did not seem favourable to the retention of iron oxide in the metal up to reaching the mould for casting. Bubbling in the mould, due to dampness or lack of venting, might induce a slight bessemerising of the metal locally. It was not certain, however, that carbon would be oxidised. At that low temperature it might be silicon which produces no gas.

Influence of Dissolved Gases.

The influence of dissolved gas was put by Fletcher in this way in 1918:—"Growing first normally to the cooling faces of the mould, the primary austenitic crystallites, as they freeze,

eject the gases they contained, when liquid, into the surrounding molten liquor. Forcing their way between the dendritic branches and stems, increasing in volume and the smaller bubbles coalescing during the advance, they strive to reach the centre of the ingot. The smaller skin crystallites, growing rapidly, close up their ranks in the rear, driving before them the gas streams as the envelope thickens." In this description one saw a possible explanation of the presence of cavities, which did not depend upon volume change in the metal. But it could only explain the cavities shown at A, B and C of Fig. 1 if the gas were out of solution and suspended finely throughout the metal before runners or risers were set; otherwise the gases, if there were no shrinkage cavities to receive them, could only occupy the space which they held when in solution, which was relatively negligible. That is to say, if there were no liquid shrinkage gas could only form cavities by ejecting the metal which had hitherto occupied the spaces.

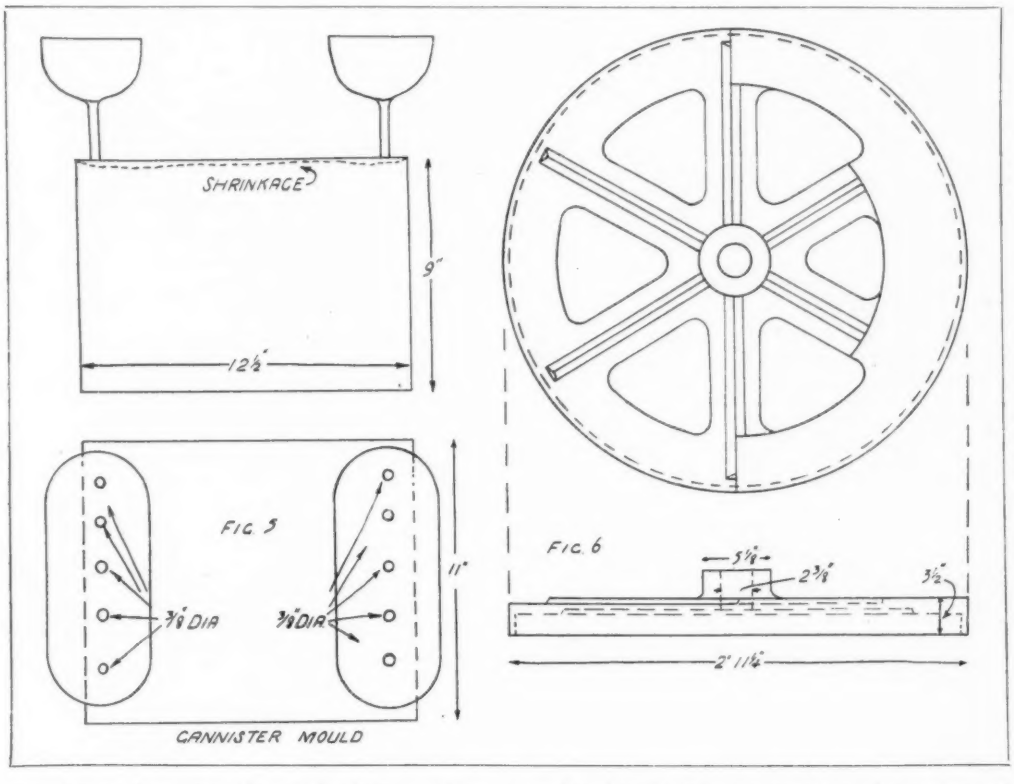
After a fairly long experience the author could not recall having seen on the surface of molten or solidifying cast iron any evidence of gases being given off except that which is often seen creeping up from the sides of the ladle, or from underneath slag on the surface of the metal—each of which cases carried its own explanation.

In proof of his views Fletcher advanced the fact that an open-sand-cast iron plate would show bubbles on its upper surface on examination when cold. These, Fletcher thought, were due to gases freed from the metal riding at the surface. But this was by no means conclusive. Let anyone cast two open-sand cast plates in hot cast iron. Let the first be left uncovered and the second, immediately after casting, be covered with a thin layer of fine dry sand, sieved on carefully. The upper surface of the first would be found to be full of holes, just under the skin, whilst the second would be as solid as if a top part had been used. If gases came out of solution in the first case, why not in the second case? There could be no question of pressure. He leaned to the view that the subcutaneous bubbles found in the first were not, strictly speaking, gases from the metal, but were formed by reactions between the rapidly forming skin of iron and iron-oxide on the surface; the oxide giving up its oxygen to the carbon, bubbles of gas were formed and held between downward-growing dendrites and under the fairly strong skin at the surface.

When gases were coming off molten steel it boiled. On solidifying aluminium alloys ejected gas sometimes produced small blisters. If, however, steel was degasified (or at any rate the gases were kept in solution over the solidifying period) the pipe became more pronounced. Probably the metal which was most gas-free was the metal which piped most readily and had the greatest apparent liquid shrinkage. Recent experiments had demonstrated that in certain aluminium alloys, when treated by a process which removed gases (included if not occluded), the liquid shrinkage factor was increased and an increase in density followed. This was also true of steel. All this evidence seemed to show that, whatever be the degree of importance of the influence of gases, there remained, at the back of it all, an independent and substantial liquid shrinkage factor, which had to be dealt with as a separate problem.

Experimental Data.

In a Paper read last year before the Falkirk Section, the author outlined some experiments undertaken by him to ascertain the amount of liquid shrinkage in certain grey irons. The irons used were of the medium order in composition. He proceeded upon this principle: A runner, of any dimension, is capable of feeding a casting, in some degree, after pouring is complete. Hence, if liquid shrinkage is to be measured in any quantity of metal, that quantity must be isolated from any supply of head metal. In moulding the upper surface of the pattern was kept perfectly level whilst the joint was kept full and sharp to the top of the pattern. When such a mould was being cast the mould filled; then, if the head was kept full, the metal ran away through the channel provided for it; at the same time there was some little pressure on the flat upper surface of the mould. When pouring ceased all metal not required to fill the mould drained away. Such a casting had no head from which to draw supplies of new metal. With each example of this kind a further mould was made and cast out of the same shank of metal. In the second case, however, the mould was provided with a 2-in. diameter riser for feeding with the rod. The one was then weighed against the other, the idea



being that equal weights of metal of the same composition represented equal volumes, and therefore, that the difference in weight fairly represented the difference in volume. In green-sand-made castings the difference was found to be round about 4.5 per cent., in dry-sand-made castings about 2.35 per cent. Further experiments with the same pattern disclosed the fact that, soon after casting, the shell of the green-sand-made casting expanded, increasing the capacity of the block by 2.737 cub. in., whilst the dry-sand-made casting increased its capacity by 0.707 cub. in. This showed that the higher resistivity of the dry-sand mould reduced the shrinkage cavity, because the forces which made for expansion were directed inwards to a greater degree than in the green-sand mould. The general conclusions arrived at were:—

(1) Grey iron shrinks round about 4.5 per cent. of its liquid volume on crystallising.

(2) If the expansion which immediately follows crystallisation be directed wholly inwards, there is a residual loss of volume, due to liquid shrinkage, of round about 1.5 per cent.

(3) Quick cooling (as by the use of chills) does not reduce the rate of liquid shrinkage, but makes for greater solidity only if solidification is so speeded up thereby as to enable new metal to reach the part concerned.

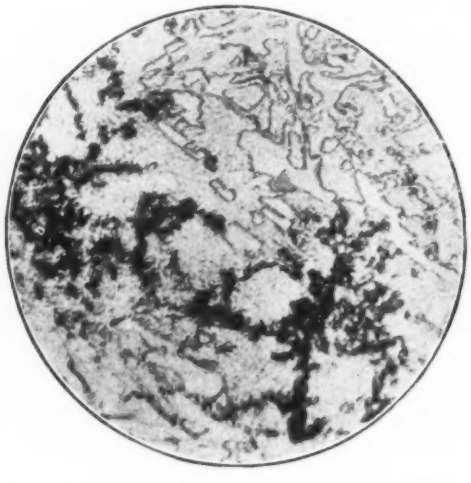


FIG. 7.—SHOWING PRESENCE OF GRAPHITE IN RAPIDLY COOLED CAST IRON.

(4) The aggregate loss of volume due to liquid shrinkage does not appear to be appreciably affected by temperature of pouring or composition.

(5) Slow pouring does not reduce the rate of liquid shrinkage, but may alter its distribution throughout the casting.

The late T. D. West, from experiments made with spheres cast in dry sand, concluded that, generally, cast iron shrinks about 1 per cent. on solidification. Later, after further experiments, he concluded that the shrinkage factor was round about 2 per cent. for sand-made castings and 4.5 per cent. for chilled castings. Now if the cavities found in castings were due solely to simple volume change, the absolute shrinkage factor for an iron of a given composition would remain constant; if the cavities were simply due to gases which had come out of solution the shrinkage factor would become a cavity factor varying with the amount of gas held in solution and that which may be released on solidification. These last factors might depend upon the vagaries of furnace practice.

In respect of the irons used by the writer in the experiments referred to above, the phosphorus contents of the metal ranged from 0.6 to 0.7 per cent. It was also pointed out that, having regard to Turner's conclusions in respect of the post-solidification expansion of phosphoric irons, that such irons, in certain circumstances, might show no residual shrinkage. In respect of experiments in plumbago and ganister moulds, which have recently been made with a view to proving that cast iron does not shrink on solidificaton, it is worthy of note that the irons used were of the phosphoric order. The writer has cast a 5¾-dia. sphere in a plumbago-lined mould, through a runner, on the joint, of 2½ ins. by ⅛-in. cross section, in similar metal, which proved to be solid to the eye. The metal analysed as follows:—Si. 2.43, C.C. 0.37, G.C. 3.1, P. 1.2, S. 0.1, Mn 0.42. On the other hand, the writer has cast many similar blocks in plumbago moulds, with low P. iron, without succeeding in getting a block free from shrinkage cavities. One such block is shown at E, Fig. 1, whilst D is the solid sphere in high P. metal.

In order to see whether a ganister mould would give solidity in the absence of any adequate source for the entry of new metal, a mould was made in ganister of the dimensions and form shown at Fig. 5. Five runners, each ⅜ in. dia., were placed at one end of the top part of the mould, and five risers of the same size were placed at the other end. The mould was kept on the stove bogie for a week, going in and out with the jobs for drying each day. It was then cast with metal of the composition—Si. 2.53, T.C. 3.66, P. 0.65, S. 0.08, and Mn. 0.42. The metal was not very hot, but was very fluid, running quietly through the mould and filling up the riser head, which weighed 50 lbs. When examined, the casting was found to have piped, in the form of a shallow depression, which covered most of the upper surface of the casting, varying in depth from ¼ in. to 3-16 in. Before closing the mould, great care had been taken to ensure that the top face of the mould be perfectly smooth and flat. The void thus apparent in the casting was about 15 cub. in., representing about 1 per cent. of the total capacity of the mould. Whether the interior is solid or not, the writer does not know, not having been able to get it sectioned. In view of these experiments, the writer cannot agree that all grey irons, when cast into plumbago or ganister moulds, do not shrink on freezing.

It was probable, however, that high-phosphorus irons showed relative solidity in such circumstances, though not when cast into green-sand moulds.

Influence of Temperature on Castings.

His experience led him to the conclusion that temperature differences did not much influence absolute liquid shrinkage, yet there was no doubt that pouring temperature had important influences on solidity in the casting. Anderson and Johnson were of opinion that the higher the temperature at which a metal entered a mould the greater would be its liquid shrinkage, and hence the weight of metal which could be poured into a mould at a higher temperature was less

TABLE I.—*Experimental Data.*

Test.		First Cast.	Last Cast.	Difference.
		Weights in lbs.		
1		228	222¾	5¼
2		230	228	2
3		232	225	7
4		226	225½	4½
5		229½	222	6
6		228		
		Analyses.		
4	C.C. ..	0.39	0.35	
	Gr.C. ..	3.27	3.38	
	Si. ..	2.51	2.50	
	P ..	0.78	0.71	
	Mn. ..	0.41	0.40	
	S. ..	0.68	0.67	
		Specific Gravity.		
4	.. ..	7.101	7.094	

than at a lower temperature. As neither writer expressly excluded cast iron from this generalisation, it might be assumed they both included it. But whilst the principle was possibly true of some grades of cast iron, it was not true of a soft iron which the author had investigated. A casting was moulded on a jar-ram turnover machine. The pattern was of cast iron, highly finished, mounted on a machined plate. The moulding boxes were uniform and machined on the joint faces. Each day, before moulding began, the sand was thrown into a single heap. Each box was given the same number of bumps

in ramming, and the air pressure was constant. Each day, eight moulds were cast out of a one-ton ladle, eight minutes elapsing between the commencement of casting to the finish of casting the eighth (Fig. 6). A summary of the data in respect of six days' casts is given in Table I. In every case which he examined, the last to be cast was lighter than the first. There was no perceptible difference in the castings except in weight; the last cast was as sharp as the first.

Graphite in Molten Cast Iron.

Some light was thrown on the subject by the analysis of No. 4 series. The one cast at the lower temperature was lower in combined carbon and higher in graphitic carbon, whilst the last cast was of lower density than the first. When the eight of that series had been cast some of the remaining metal was caught into a hand-ladle and a little was poured, in as thin a stream as possible, into cold water. A small button of this of some 6-mm. diameter was polished and etched, and a microphotograph taken. The microphotograph (Fig. 7) showed the unmistakable presence of graphite, with a matrix of cementite and martensite. From the lay-out of the graphite particles it might fairly be assumed that they formed a number of flakes which were broken up in the crunch consequent upon chilling. It was too often assumed that graphite could not exist in ordinary grey irons whilst molten. From the analysis it was apparent that the metal in question was hyper-eutectic in respect of carbon; but so were a good many cast irons used in the foundry. In this case the graphite had probably come from decomposed primary cementite.

The view that molten iron tended to expand in the mould might find some support in respect of irons of the type here mentioned. If graphite was liberated in the metal whilst liquid, the latter would tend to gain in bulk before freezing. If such metal was in the mould before separation took place, and there was no opportunity to throw back the metal up the riser or runner, the metal would be denser than if cast at a lower temperature. It was generally admitted that pressure alone was sufficient to hinder the formation of graphite. This would seem to afford some explanation as to why castings which were cast hot were denser than those which were cast with dull metal. Whether this was equally true of eutectic or hyper-eutectic irons was not quite so certain.

Smalley had presented a mass of original data upon the subject, which was of immense value to every foundryman. The author did not agree, however, with Mr. Smalley's principal conclusion, namely: "Cupola-melted grey iron, of normal chemical composition, does not shrink on solidification, if poured with a sufficient degree of superheat, and if cooled faster than a certain critical rate." That conclusion was based on results achieved by the use of chills on a bed-plate casting and on the results obtained from the use of various compositions cast in sand and chill moulds. Nothing in Smalley's data proved that the more rapid cooling reduced absolute shrinkage. It had been shown by the writer that quick cooling did not reduce shrinkage, and that chills only gave increased solidity or fullness if solidification was thereby so speeded up that new metal could flow to the part concerned whilst a liquid channel was open to it. This may be proved very simply. Specimens B, C, D and E, of Fig. 8, are sections of four cylindrical block castings, of

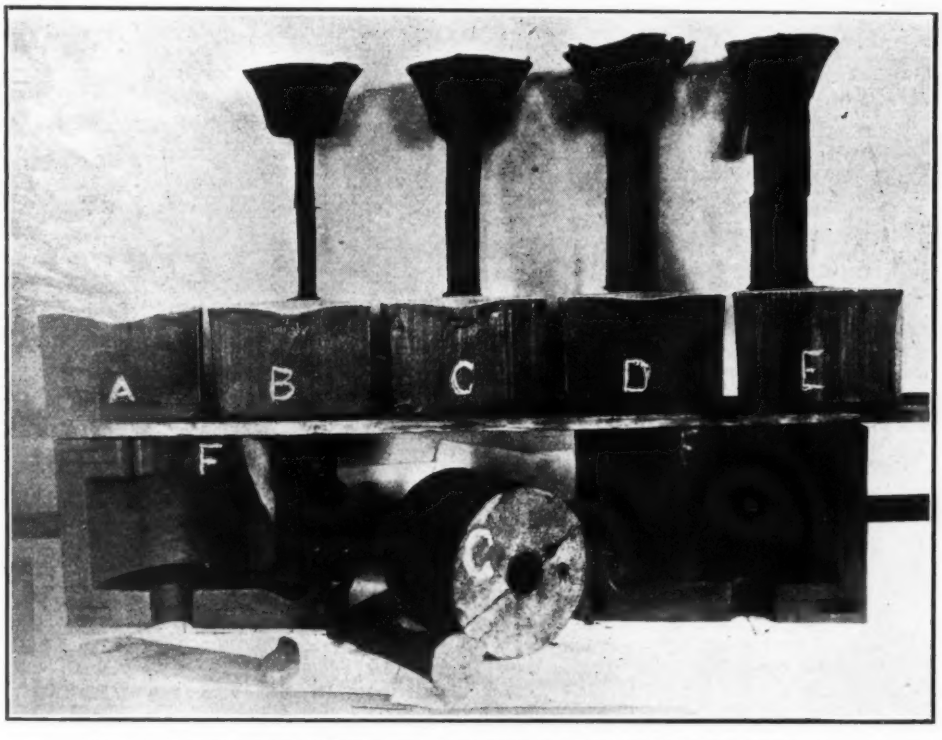


FIG. 8.—EXPERIMENTS TO SHOW THE INFLUENCE OF SIZE OF RUNNER PIPING.

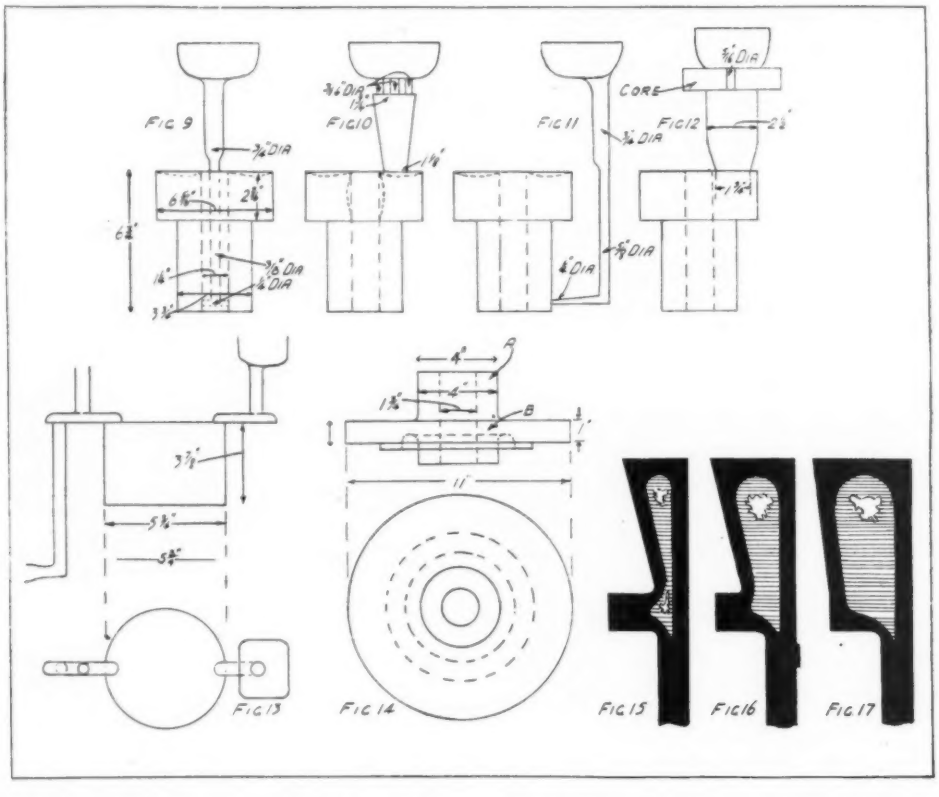
the dimensions shown in Fig. 13. Each mould was made out of the same heap of sand. The bottom face of each mould was formed by a chill, which was as big as the pattern—in fact, the chills were similar castings. The head of each was 9 ins. The diameter of the runner of B was $\frac{5}{8}$ in., of C $1\frac{1}{8}$ in., of D $1\frac{5}{16}$ in., and E $2\frac{1}{8}$ ins. These dimensions give cross-sectional areas as follow:—B 0.31, C 0.99, D 2.1, and E 3.5 sq. ins. Rate of pouring was equalised by placing suitable cores in the bottom of the runner basins of C, D and E, which were lifted out with a rod after pouring. All four were cast in quick succession out of one shank of iron, at an initial temperature of about 1,345 deg. C. The metal had the following composition:—T.C. 3.07, Si. 1.41, P. 0.31, S. 0.094, and Mn. 0.41.

The whole were cast within 80 seconds, so that the temperature variation could have been very small. B was cast first, and so on to E. Specimen A, Fig. 7, was cast, under similar circumstances, on another occasion. The mould was made, however, as shown at Fig. 13, with provision for all metal to flow away which was not necessary to fill the mould. A chill, equal in size to the pattern, was placed on the bottom face, and the mould was cast, some 16 lbs. of metal

being run through it. The metal used had the composition:—T.C. 3.48, Si. 1.51, P. 0.39, S. 0.11 and Mn. 0.50.

The series A to E show a decided progression. A, having no head metal whatever, pipes in somewhat the same amount as it would have if no chill had been used. B shows a decided pipe, due to the inability of the small runner to keep liquid long enough to feed the void consequent on shrinkage; and so, progressively, to E, which is quite solid.

In the two half-moulds made of cast iron, shown at F F, Fig. 8, the writer casts clutch blanks, a casting from the chill mould being shown at G. If very fluid metal be poured into it, the mould fills, and the metal in the riser can be seen to freeze instantaneously. When pouring ceases, the metal in the runner stands up, roundly convex, owing to surface tension; but this quickly flattens and changes into a shallow pipe. This shows that, even with such a rapid rate of cooling, a shrinkage loss needs to be made up from the runner. This noticeable loss, however, is not the total shrinkage loss. Heat conduction is very rapid, and a good deal of shrinkage is compensated for whilst pouring is proceeding.



Influence of Length of Cooling Range.

Largely owing to Smalley's work, a good deal of attention had been directed to the increased solidity which could be obtained in suitable circumstances by the use of iron having a short freezing range. Such irons were also the harder having low silicon and phosphorus, whilst the long freezing range irons had high silicon and phosphorus. If a given volume of metal be taken, hard irons tend to shrink more than soft irons. How, then, is it possible to account for greater solidity in a casting made in hard iron than if cast in soft? Whilst absolute shrinkage must be measured as a proportion of the whole of the metal used—*i.e.*, runners, risers and casting together—the practical problem related to the casting only. If it was sound it was a matter for congratulation that runners, risers, heads and composition had been so arranged that they each played their part in securing the result. The harder, denser cast irons were more freely piping, and consequently might be expected to be more readily self-feeding. But that was not to say that such irons did not shrink in solidifying.

If two representative metals were taken of the following orders: (1) T.C., 3.50; Si, 1.25; Mn, 0.60; P, 0.20; and S, 0.10 per cent., and (2) T.C., 3.30; Si, 2.30; Mn, 0.60; P, 0.78; and S, 0.10 per cent., there was a great difference in the mode of solidification. In (1) crystals would begin to grow when the temperature was as high as 1,230 deg. C., and with a further fall of 80 deg. C. its whole volume would be solid except some 2.5 per cent. of phosphide eutectic, which froze at about 960 deg. C. In (2) crystallisation would begin at about 1,165 deg. C., and with a further temperature fall of 16 deg. C. the only remaining liquor would be that of the phosphide eutectic, which would here amount to 9.75 per cent. of the total volume, also freezing at about 960 deg. C. Obviously the harder iron had the longer freezing range from incipient to main solidification, but it was then nearly complete, whilst the softer iron had yet 9.75 per cent. of its volume liquid. In the first case, freezing having begun at a higher temperature and proceeding more slowly to main solidification—probably in a more fluid liquor than in the case of the softer iron—the early formed dendrites might tend to drift away from their attachments in response to a downward sag of the metal consequent on a demand for more liquor from below. On the other hand, in the soft iron, the crystal skeletons having been formed at a lower temperature, and more quickly, were buoyed up somewhat by a more viscous liquor, and the growing tendrils might quickly grow right across a section, leaving shrinkage to proceed within intercrystalline compartments and preventing the flow of liquid to isolated heavy sections. Hence it was possible to reconcile the paradox that an iron with the higher absolute shrinkage might give a casting with the greater solidity.

Influence of Slow Pouring.

The practical foundryman had evolved his practice with a view to the elimination, as nearly as possible, of shrinkage defects. First, he chose metal of the right composition, then he cast very slowly; he might use chills, the feeding rod, or provide a substantial head of metal to serve as a reservoir to meet the requirements of the cast-

ing. Slow pouring, with hot metal, had an important sphere of usefulness. For many small troublesome jobs it was very successful, providing an easily applied and certain cure for many otherwise perplexing problems. The author had found it particularly useful as an aid to producing pulleys and gear blanks up to a weight of about 2 cwts. For pulleys he had found a runner to casting ratio of 0.25 sq. in. per cwt. of casting very successful. Such a runner, in the form of a rectangular sectioned slit, placed on the rim, produced a clean casting, clean on the rim and in the boss when bored. The usual method of casting a pulley was by placing a runner on the boss which needed to be fed with a rod; it had very indifferent results, so far as soundness was concerned, unless such a boss was chambered. For castings of heavier section than that of a pulley, a runner to casting ratio of not more than 0.2 sq. in. per cwt. of casting was sufficient.

He had never secured a definitely sound casting where any section was greater than 2 in. by means only of the pencil runner. A casting which had given a great deal of trouble was shown at Fig. 9. It was machined all over, a keyway being cut down the bore, and teeth cut all round the larger diameter. Slow pouring was tried with runners, as shown at Figs. 9, 10 and 11, but quite satisfactory castings could not be obtained, shallow depressions appearing at places though the interior was quite solid. A further step was taken. What was in effect a small feeding head was placed as shown at Fig. 12. The metal fell through this from the runner basin into the casting, filling up the head last. With this form of runner very different results arose from the use of different metal mixtures. With an iron of the order of Si, 2.5; T.C., 3.6; Mn, 0.6; P, 0.5; and S, 0.1 per cent., the result was that, when the head was knocked off the casting, a spongy place was disclosed just below it in the casting whilst the head was quite solid. When iron of the order of Si, 1.5; T.C., 3.4; P, 0.3; Mn, 0.6 and S, 0.1 per cent. was used, the casting was quite solid throughout, but a deep pipe appeared in the head at the top, just under the pencil runner. The pipe had a volume of about 1 cub. in. It was clear, however, that in both cases the casting needed feed iron. The iron with the shorter freezing range was the more readily feeding iron, and hence gave the more solid casting.

Filtering Cast Iron.

In a previous Paper the author has given his views as to the reason why slow pouring, with the avoidance of risers, was so relatively successful. It had nothing to do with filtering. Fluid iron could not be filtered—though large lumps of non-metallic matter might thus be prevented from going down the runner. In fact, slag was as often found to have gone down a pencil runner as down an ordinary one. Perhaps a contributory cause was that the metal used must necessarily be very hot, which also meant that any slag which was about would also be very fluid. Further, the success of the method had nothing to do with gas, entrained or otherwise. Though a slowly-run casting took a longer time to pour, less metal passed through the mould, for no riser was used; hence the metal in the mould was sooner quiet. Though the runner was small it had more heat in its immediate surroundings than a larger runner would have, owing to the longer time during which hot iron had been passing through. Consequently it remained liquid long enough to meet the requirements of liquid metal called for by shrinkage due to an advanced solidification in some parts of the mould, and various degrees of incipient solidification in others. By the time the runner had frozen up the partially liquid casting would be interwoven by a sort of lattice-work of dendrites which quickly grew together, dividing out, more or less generally, the sum of cavity remaining due to solidification of the liquor. The shrinkage then took the form of minute intercrystalline spaces. At. Fig. 14 is shown a sketch of a casting made with a pencil gate. The bore is important, and, if cast in the ordinary way without feeding, cavities sometimes appear at B. It is cast with invariable success with the pencil runner. One such casting was broken and density determinations were taken of specimens from A (the first place to solidify) and B (the last place to solidify). The specific gravity at A was found to be 7.075, whilst that of B was 6.977. The last place to cool was therefore 1.38 per cent. less dense than the first place to cool. This shows that, though the structure of the part B was reasonably close, there had been a more parsimonious distribution of crystal-making material.

Rod Feeding.

Feeding with the rod, or pumping, was a very laborious and doubtful method of securing solidity. The gear blank, for example, shown at Fig. 9, would rarely give a good casting by pumping, however big the riser might be. Almost invariably a cavity would appear in the bore when machined, at the opposite side to where feeding had taken place. The same characteristics would appear in many castings of a similar type, such as commutator bushes or couplings. The peculiar thing about it was that the cavity in a fed casting was often greater than that in a casting which was cast with an ordinary runner and riser and then left. The first point which suggested itself was that a casting which was being fed with a rod was thereby precluded from benefiting in any way from the expanding forces within the casting. Another explanation arose from the probability that the feeding rod, as it rose and fell in the casting, had particles of oxide rubbed off it, which particles were pushed or swirled away round the core. Any sponge formed at a later stage by reactions between the oxide and carbon could not be dislodged by continued feeding, the metal being pasty. That this suggestion was quite within the bounds of possibility might be proved at any time when feeding was taking place. If, when feeding was just completed, the pasty metal left in the riser was watched, it would be seen to be swelling. A piece of that metal cut off when cold would be found to be honeycombed, due to the reaction mentioned. It seemed very probable that the feeding rod only gave absolute solidity directly under it. The rod aided the passage of new metal into the mould generally during the early stages of incipient solidification, but it was doubtful if, when the metal became really "mushy," the rod could do any good at all except just below it. When the "mushy" stage had been definitely reached by the metal in the mould, the value obtainable from rod feeding was confined to the region of the riser or runner concerned.

Chills and Denseners.

In respect of chills or denseners, it was essential to remember that their use did not reduce the amount of liquid shrinkage. Their function was to hasten the rate of solidification of the part concerned, so that new metal could flow to it through surrounding sections whilst such sections were liquid. It followed that a heavy part connected with a thin section required to be cooled more quickly (and hence needed heavier chills) than a part of the same dimensions connected with sections which were not so thin. It was often remarked that the use of chills sometimes resulted in the chilled part being solid at the expense of some neighbouring section. This was proof that the hasty freezing of such a heavy part did make necessary the supply of fresh metal to make good the loss due to solidification If such neighbouring sections, in their turn, could find no source from which to make good the loss, the cavity or porosity would simply be transferred to that part. The obvious remedy was to hasten solidification in the heavy part, so that its losses of liquid were made good whilst the runner was still continuously open to it.

The use of chills was not without disadvantage. If the only part upon which they could be placed was to be machined trouble was sure to come, sooner or later. The same weight of chill, when used against a soft iron as against a hard iron, would often result in unmachineability in the latter case. This was more disturbing when it was remembered that the harder irons required heavier chilling than the softer. One could only feel quite safe in the use of chills when they could be placed on the opposite side of a section

to that which was machined. For tightening up inner wall junctions the chill was indispensable.

Feeding Heads.

There remained to be referred to the use of feeding heads. The hot runner on a casting always functioned as a head of metal, upon which the casting might call, whilst liquid. A riser might also, but very infrequently, serve as a kind of head of metal for the same purpose. The cross-sectional area of these was necessarily very small and consequently did not remain liquid long enough to feed every part of the generality of castings.

Head feeding might be called gravity feeding. If the thickness of the metal above any section was greater than such section, it would tend to remain liquid longer than the section below it, and by gravity would meet its demands for new liquid.

In respect of the three types of head shown at Figs. 15, 16 and 17, the first is useless for feeding purposes, though it might have some little use as a dross head. By the time that the section below the flange was quite frozen the flange and head would also have frozen in the areas marked. The lines of demarcation between liquid and solid were not as clearly marked in a casting as they appeared in the sketch, because the process of solidification consisted of the growth of dendrites from the cooling faces, which soon became a solid mass—it might be likened to undergrowth—the pioneer crystallites continuing to forge ahead through the liquid, reinforced by their own branches and planes. Consequently, at the stage when the casting was solid to the degree shown by the sketch, the remaining core of metal would be intersected with elementary crystal growths. At such a stage the supply of liquor from above to the flange would be insufficient; the passage would be frozen too soon. Consequently, when the flange was cleaned up, a series of holes would be found in it, or the whole of the region under the head would be very open and porous. The difficulty which arose with any section which did not feed solid naturally was further emphasised when the moulder made large fillets, thus enlarging the pools of metal which were cut off from any supply of head metal.

The head shown at Fig. 16 was good, but, as shown by the isothermal lines, not without danger. The third was the best. It is perhaps the most expensive, and might entail the use of a great weight of metal, but if the casting was important such a head was a good investment.

The author wishes to express his thanks to Mr. R. K. Tullis, manager of the Kilbowie Laboratories, for the photographs, microphotographs, analyses, and density determinations which he had made use of, and to Messrs. D. & J. Tullis, Kilbowie Ironworks, for permission to carry out the experiments which had been referred to.

Which Shop to Blame?

By J. McL.

Post-mortems on defective castings take place in the best regulated works, and we are afraid there is sometimes greater anxiety to determine who is to blame than what was responsible for the casting being a "waster." Antipathy takes the place of friendly rivalry in many engineering works, and the head draughtsman, and the foremen of pattern, moulding and machine shops, watch each other very closely, and, instead of co-operating for the common good, are extremely critical, and their criticism is not invariably of a helpful kind.

Every works is a little world where all kinds of emotions are in action, and it may be frankly admitted that it is not possible to eliminate altogether the causes of dissension and misunderstanding in the average factory. Perfect harmony may be unattainable, but the reasons for a good deal of the friction are so flimsy, so altogether absurd, that to expose them is to sweep them away. In all engineering works this is more or less the case, and in foundries where the pattern shop and moulding shop are under different heads the same condition exists. Instead of this benefiting any shop, it prevents any of them from pulling their full weight. The heads of the departments are invariably to blame for this unsatisfactory state, but it does not stop with them, but permeates right down to the youngest boy, and thus we frequently find one shop more anxious to hinder the work of another shop than to increase its own efficiency.

The writer can remember, as an apprentice, being prompted to say certain things in the event of the works manager inquiring as to why a casting was bad. In shipbuilding yards when a pattern has been made from a template tried to place there is often much disputing, when there is difficulty in erecting the casting, as to whether the ship fitter, the patternmaker, or the moulder has made a mistake. Fitters do sometimes erect work temporarily to facilitate work being fitted, and they do not always re-erect it in precisely the same way.

It is often possible to rectify the bad work of one department in another department, as, for instance, a pattern may be so badly constructed that it might easily be condemned; but the foreman moulder, instead of doing this, may have it modified to suit him or may alter his method so as to utilise the pattern. In the same way a bad casting may be carefully set upon the marking-off table and as carefully machined and thus saved; but if there is antipathy between the head of these departments, the casting will be condemned. A mistake on a machine may be often put right by the insertion of a liner in erecting. Modifications of this kind can frequently be made at a very small cost and without the need for any discussion as to who is to blame.

Some firms have a daily conference of the departments, and there is much to be said for the practice, especially in large works where the heads of departments do not come into continuous contact, as is the case in small works. In this way a direct interest is taken in all new developments within the works, and fresh orders and also the decrease or increase of tonnage leaving the works can be discussed. But perhaps the greatest advantage of such a daily talk is that it brings the foremen together, and they can thus elicit useful information, and by informing others of their intentions, enable these to consider how they will deal with jobs as they come along. The lunch hour is also a good time for these talks between foremen, and this has the advantage over the morning talk in that it is less informal.

The need for consultation with heads of departments is greatest when any alteration from a standard is introduced or an altogether new class of work is being undertaken. The draughtsman has not often the practical experience of the patternmaker, and it is often possible, by modifying the design in a simple detail, to considerably reduce the work of the moulder. It is surely a mistake to wait until the pattern is actually being constructed before an alteration is made, in which case a new drawing has to be made and the patternmaking has to be held up. It is likewise an advantage for the patternmaker to discuss the method of moulding with foundrymen before the pattern is built; for a moulder does not like to make his joints in a way that he does not approve, which, indeed, his experience has taught him is not the best way. There are machining problems that are also best talked over by the machine shop foreman and the foreman patternmaker before the construction of the pattern is commenced.

Syphonic Action.—Water may be lifted by syphonic action providing the total lift is not over 34 feet.

To Find Length of Belting Required for an open drive the following formulæ is very useful and quick. Let A = dia. of the driving pulley, and B the dia. of the driven pulley. Then $\frac{A+B}{2} \times 3\frac{1}{4}$ + twice the distance between the shaft centres, gives the length of belting required, no allowance being made for piecing.

Aluminium-Alloy Permanent-Mould Castings.—I.*

By Robert J. Anderson, D.Sc.

INTRODUCTION.

Aluminium-alloy castings are produced by three main processes in the United States—viz., sand, die, and permanent-mould casting—and the fields of application, properties and qualities of castings made by these three different processes are markedly different. The qualities and properties of castings produced by the three methods would naturally be expected to differ because of inherent differences in the modes of manufacture. Aluminium-alloy castings are also produced by the semi-permanent mould process (using sand cores), and by the Cothias system. These two latter methods will not be considered in detail here. Since the properties, qualities, and fields of application of parts produced by the different methods are markedly different, the purchaser of castings is no more justified in simply ordering aluminium-alloy castings without proper consideration of the specific method by which the casting should be made (as well as the alloy to be used) than he would be in ordering ferrous castings without specification as to whether they are to be malleable, grey iron, or steel.

Many designing engineers and purchasers of castings do not thoroughly appreciate the complexities of the aluminium-alloy casting industry, nor differentiate sharply enough among the products made by the three main casting processes. This is not altogether the fault of such engineers and purchasers, since for one reason manufacturers of castings have not taken the trouble to enlighten them, and for another reason the permanent-mould process is new as a production proposition. The object of this series of articles is to discuss the fields of application, properties, and mode of manufacture of aluminium-alloy permanent-mould castings, and to give comparison of these with castings made by the other processes. The information is presented so as to assist the consumer of castings in making a judicious choice of the correct type of casting for particular purposes.

As is well known, in the production of castings, interest has always been shown in attempts to devise and employ moulds that would be permanent or semi-permanent in nature, thereby eliminating the procedure of destroying the mould with every pour, as in sand practice. This has not been confined to aluminium-alloy work, but much work has been done in this direction as regards iron castings. The principles involved in the production of castings in permanent moulds have been known and practised since 3000 B.C., but the cast-iron mould, as it is known and used to-day, has been employed only about 150 years. Pre-historic man used stone and bronze moulds of a permanent, or semi-permanent, nature for casting weapons, ornaments, and tools. To-day, semi-permanent moulds of baked refractory materials which are expected to last for 500 to 2,000 casts are employed. Sand castings were first produced in about 1370 A.D. Metal moulds were employed also about the middle of the fifteenth century, with the advent of printing. A survey of the historical development of permanent-mould casting has been given by the writer and M. E. Boyd.†

The creation of permanent-mould casting as an important and separate industry is a relatively recent achievement, and in the aluminium-alloy field the process has advanced from the position of a small-scale method to that of an important production process in a comparatively short period of time. Die casting developed with the growth of large production methods in the United States in the manufacture of interchangeable parts, and aluminium-alloy die casting started about 1914. Prior to 1912, practically all aluminium-alloy castings made in the United States were produced by sand founding. The permanent-mould process as applied to aluminium alloys was slow in developing because of difficult mechanical, thermal, and metallurgical problems involved, but the fundamental principles of successful casting have now been fairly well established. There are still many problems to be worked out in this process, but the method has been developed to the point where millions of castings have been produced, and volume production is made in competition with sand casting or die casting. Technically, it is possible to produce practically any type of casting in a permanent mould; commercially, it is still not feasible or economical to attempt production of certain types of parts.

At the outset, in discussing the permanent-mould process for producing aluminium-alloy castings, it is important to differentiate sharply between this process and the die-casting process. In trade parlance, there is still considerable confusion in the use of terms applied to describe castings produced by different processes involving metallic moulds, and it is important to distinguish sharply what is meant by a permanent-mould casting. In the trade, the term "die castings" is often applied unknowingly to actual permanent-mould castings, and this is incorrect and misleading, since these castings are made by entirely different processes, and the mechanical properties and relative soundness of each are markedly different. Castings are produced by other processes involving the use of metal moulds—*e.g.*, centrifugal casting and slush casting—but these have not been applied to the light aluminium alloys, and need not be taken up here .

Permanent-Mould Casting Process.

A permanent-mould casting is defined as a finished, or semi-finished, casting made by pouring a liquid alloy into a metallic (usually cast-iron) mould, the alloy entering the mould under the force of gravity solely. The process is similar to sand casting in that it involves a mould, cores, and pouring by gravity. The terms "hand-poured die castings" and "gravity-run die castings" have been applied to the products obtained by the permanent-mould process, but these terms are quite unnecessary. By definition, the permanent-mould process is readily distinguished from other processes involving the use of metallic moulds. It is also generally understood in permanent-mould work that metal (steel or cast-iron) cores are used. Objection has been raised to the use of the term "permanent mould" on the ground that the mould (or cores) are really not permanent, but require repair and upkeep, and eventually wear out. Of course, nothing is actually permanent, but when several hundred thousand castings can be poured in a mould, either with or without repair, then such a mould may be properly regarded as permanent for all practical purposes. Collapsible steel cores wear out much more rapidly than moulds, such cores lasting for 5,000 to 20,000 casts, with an indicated average of 10,000, referring to certain alloy steels.

In the permanent-mould process, when using collapsible steel cores, the liquid alloy is poured by hand into a previously heated and assembled mould, and, after a short lapse of time, after the alloy has frozen, the core pieces are removed, the mould parted, and the casting taken out. The mould halves are then again brought together, the core pieces are inserted, and the mould locked, when it is again ready for another pour. The process is simply repeated over and over again. Permanent-mould castings are not so easy to make as the foregoing short description might indicate, and, in point of fact, they are normally much more difficult to produce than either sand castings or die castings.

Permanent-mould casting is a quantity-production process, and not many parts can be considered economical for production in lots of less than 500 to 1,000. This is so because of the expense of making the moulds. Mould costs in permanent-mould work are, however, not normally so high as die costs in die casting.

* The first of a series of six articles dealing with the production of aluminium-alloy castings by the permanent-mould process, and the applications and properties of these castings.

† R. J. Anderson and M. E. Boyd, "The Production of Castings in Permanent Moulds," Paper before the Institute of British Foundrymen, Newcastle-on-Tyne meeting, June, 1924.

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Semi-Permanent Mould Casting Process.

The term semi-permanent mould process is applied to casting in metal moulds, using a sand core, or to casting in moulds made of baked refractory materials. In the former, the mould is permanent, but the core is destroyed with every cast, while in the latter the mould is expected to last only 500 to 2,000 casts before it wears out and must be replaced. In the latter, sand cores are ordinarily used. The process involving cast-iron moulds and sand cores is applied to difficult coring jobs—*i.e.*, where it would be very troublesome or impossible to use steel cores which would have to be extracted from the mould before removing the casting. In the United States this method has been applied mainly to aluminium alloy vacuum-cleaner castings, which present troublesome coring problems—*i.e.*, from the point of view of using steel cores. The baked refractory semi-permanent mould has not been used extensively, but is being applied here and there for fairly simple castings where the quantity involved does not warrant the expense of making a cast-iron mould.

When using sand cores in cast-iron moulds, the alloy is poured by gravity in the ordinary manner, the mould parted, and the casting removed, as in regular permanent-mould practice; the core is knocked out of the casting, as in sand practice. A new core is then inserted in the mould, the mould locked, and the process repeated. The term semi-permanent mould is strictly applicable only to the refractory type of mould, which lasts for a limited number of casts.

Die-Casting Process.

A die-casting is defined as a finished, or practically finished, casting made by forcing a liquid alloy into a metallic mould or die by pressure. It is pre-supposed that little or no machining, other than drilling for screws, bolts, and the like, will be required to put the casting into condition for use, and in many cases the required holes are cast in the part as made. Die castings are sometimes confused with die pressings, which are made by the hot pressing of metals and alloys, and die pressings are often referred to as die-pressed castings and die castings. A die-casting is a finished casting in the general meaning of the term, in contradistinction to a rough sand casting, for which a greater or lesser amount of machining is usually pre-supposed. A permanent-mould casting may, of course, be a practically finished casting

Emphasis should be laid upon an essential feature in the die-casting process which sharply distinguishes it from other processes involving metallic moulds—viz., the alloy is forced into the die-cavity by pressure. In the case of aluminium alloys, air pressures of up to 1,500 lbs. are used, and the mode of manufacture of air-pressure die-castings is the cause of their chief disadvantage—viz., excessive porosity. The occurence of blowholes and porosity is a feature inherent in commercial die castings made under high pressures. Die-castings in tin-, lead-, and zinc-base alloys are usually made by mechanical (plunger) pressure, while aluminium-alloy castings produced by the Cothias process are made by mechanical pressure. The surface skin of the usual aluminium-alloy die casting is normally sound and smooth, but the interior of the casting is unsound and blowholey, due to variable contraction of different sections and the entrapping of gas and air.

Die-casting is essentially a quantity production process, and but few parts can be considered economical die-casting jobs in lots of less than 1,000. This is necessarily so because of the heavy cost of designing and preparing the necessary dies; in small lots, the heavy die expense will be proportionately reflected in the cost of the castings. The cost of any die-casting must normally be less than the cost of producing a sand casting plus the cost of machining to a finished casting equivalent to a die casting.

Sand Founding.

The bulk of the production of aluminium-alloy castings has been made hitherto by sand founding. The production of castings in sand consists in pouring the liquid alloy into a previously prepared sand mould of the required size and form, the alloy assuming the shape of the mould cavity and retaining that shape when frozen. The mould is always made of some kind of sand rammed into a box, and sand is used for the cores. Skilful foundry practice, especially in moulding technique, is highly important in sand founding. This is not the case in permanent-mould work, where operatives have only to follow a simple set of rules regarding the assembly of moulds, pouring, and the removal of castings. A sand casting is normally an unfinished part, and machining is usually required to put it into condition for assembly or use. The process has a particular field in the production of parts with difficult coring and for large castings, as well as for jobs where only a few castings are required. Both the mould and cores are destroyed with every pour in sand practice. The principles of sand founding do not require detailed discussion here.

In the second article of this series the advantages of aluminium-alloy permanent-mould casting—as compared with sand casting and die casting—are discussed.

Proposed Institution of Fuel Technology.

At a meeting held recently in London of persons engaged in different branches of fuel technology, it was agreed that the formation of an institution was desirable, having as its principal object the consideration and discussion of all matters relating to fuel.

Whilst there are numerous institutions in existence which give casual attention to fuel questions in connection with the particular industries represented by them, the scientific utilisation and treatment of our fuel resources has become of such vital importance to the country that an organisation having as its sole purpose the consideration and discussion of every aspect of fuel technology, both in the field of original research and in relation to the reduction of fuel costs in our national competitive industries, is essential.

At the above meeting a Special Committee was appointed to take the necessary preliminary steps to inaugurate such an institution, and this Committee has prepared a carefully selected list of several hundred prominent men engaged in various branches of fuel technology to whom it is suggested that invitations be issued to a general meeting in London to discuss the formation of an Institute of Fuel Technology, and to appoint an organising committee to consider its constitution and scope.

Sir William J. Larke, K.B.E., Director of the National Federation of Iron and Steel Manufacturers, has kindly promised to act as chairman at this meeting.

The Committee, whose names are appended, feel that much greater weight would be given to the invitation if it were supported by as large a number of names as possible to ensure that every branch of fuel technology is represented. It has been suggested that the meeting should be held on Friday, March 5 next, at 3 o'clock, at the Institute of Civil Engineers, Great George Street, London, S.W.1.

The provisional committee is constituted as follows:—David Brownlie, 46, Grange Road, Ealing, W.5; Edgar C. Evans, National Federation of Iron and Steel Manufacturers, Caxton House East, London, S.W.1; S. McEwen, Aldwych House, Aldwych, W.C.2; Sydney H. North, 3, Amen Corner, Paternoster Row, E.C.; and Lt.-Col. N. G. Thwaites, 3, London Wall Buildings, E.C.

To Test White Lead for Adulteration, the following method is reliable:—Place a small piece of lead in a small hole made in a piece of ordinary charcoal. Obtain a bunsen burner, and with the aid of a blowpipe, direct the flame (the blue part) upon the lead. This must be done carefully and steadily. If the white lead is reduced to a small bright piece of metallic lead, it is undoubtedly pure. Should no metallic button be produced, the white lead contains impurities.

Some Further Notes on Pearlitic Cast Iron.—Part I.

By J. E. Hurst.

These notes are intended to form a continuation of the notes on this subject presented by the writer in the form of a Paper* before the London Branch of the I.B.F. in October, 1924. Extensive references have been made to this Paper both by those connected with the development of this special iron and others, *e.g.*, the engineering correspondent to the "Glasgow Herald." At the time of writing, in October, 1924, the real information on the subject of pearlitic cast iron was very scanty, and whilst in this respect the position is not very much altered to-day, certain fresh statements have been made by authoritative persons which modify in several particulars the notes which the writer made at that time.

The writer is in no way connected with the development of the Perlit process, and from this point of view is in no way qualified to give an authoritative interpretation of the process. For the above reasons, however, the writer is desirous of taking this opportunity of amplifying his previous notes, making use of the information respecting the process which is available to the general public. No apology is really necessary for discussing a subject which is claimed to be of such vital interest and importance in modern foundry practice.

The original title of pearlitic cast iron has been modified recently to "Perlit" cast iron, and the process of manufacture is now referred to as the Perlit process. This designation will be adhered to in the following notes.

In attempting to define Perlit cast iron and to draw a distinction between this and cast iron produced in a normal manner having a pearlitic structure, the writer previously attached considerable importance to the statements of the German authorities at that time. The definition deduced by the writer was as follows:—"Perlit cast iron is a cast iron having essentially a low silicon and low total carbon content. This cast iron, when cast normally, would have a white fracture, but when cast in warm moulds or cooled slowly in the moulds under special conditions has a structure consisting solely of pearlite and graphite. The composition and rate of cooling are varied to comply with these conditions for any particular thickness."

The fundamental distinguishing feature of Perlit iron, according to this definition, is that it should normally be of such a composition as to possess a white fracture. The conversion of such white irons into grey machinable irons having a pearlitic structure by such a simple expedient as the Perlit process has always been a matter for considerable doubt in the author's mind. Foundrymen appreciate that cast iron in castings of ordinary dimensions generally solidifies in the grey machinable form. As the silicon content is gradually reduced the iron continues to solidify grey until a certain percentage is reached below which it solidifies as white iron. In this state it usually requires a prolonged annealing treatment (*e.g.*, malleable castings) to render the iron soft and machinable. The direct conversion of such white iron in the simple manner of the Perlit process to a grey machinable iron is the goal of many iron-foundry metallurgists which has not yet been attained.

With silicon contents in the immediate neighbourhood above this what might be termed "critical" silicon percentage there is always the possibility of local surface chilling or the occurrence of mottled iron or chilled spots, all of which might be regarded as transition stages between the grey and the white varieties. For this reason the minimum silicon percentage allowable in general foundry practice is always somewhat higher than the above critical percentage. Whether the Perlit process enables a lower silicon percentage to be used than that generally allowable still remains to be actually demonstrated, but this is what is probably claimed in the revised definition† of Perlit iron. This revised definition is contained in the following extract:—"... the two fundamental features of the process are that a lower silicon iron than could be used in a cold mould is poured into a mould heated to that temperature which the inventors have found will produce an iron of pearlitic structure, the second feature that this structure prevails throughout a complicated casting, and is associated with a graphite structure better than usual."

The fundamental features embodied in the writer's own definition, which were based upon the statements of Professor Bauer and H. T. Meyer, of the Lanz foundry, were definitely disagreed to by Mr. Young. The writer's original definition is therefore incorrect, and the above definition by Mr. Young must be taken as authoritative.

Properties of Perlit Cast Iron.

The properties claimed for Perlit iron have been officially set out in a pamphlet, No. M1, recently issued by the British Perlit Company, Limited. There is very little difference between these and the original properties as outlined in Prof. Bauer's original Paper, and in the writer's own Paper previously referred to. It is of very great importance to note that these claims are not nearly so ambitious as some of the claims which have been made in the various correspondence which has appeared on this subject. For example, no official claim has been made that Perlit cast iron is in any way ductile or malleable in the manner generally understood.

The claims outlined in the official pamphlet can be briefly summarised as follows:—(*a*) Perlit iron is uniform, reliable, and tough; (*b*) Perlit iron can be produced of high strength; (*c*) Perlit iron has great resistance to fatigue and fatigue impact; (*d*) Perlit iron has great resistance to wear; (*e*) Perlit iron is a non-growth iron and resists the action of heat; (*f*) Perlit iron has good machining qualities; and (*g*) the strength of Perlit iron will be uniform throughout all sections, and Perlit iron is more uniform and free from defects. Whether the properties claimed for Perlit iron are superior to those which can be obtained by the ordinary means at the disposal of the foundryman has not been demonstrated. It is here where most of the confusion of thought arises, and it is to be hoped that the deplorable lack of comparative data substantiating these claims will be speedily remedied by the British authorities. The simple expedient of publishing the test figures and comparative fractures of the same material, in forms of equal dimensions before and after the Perlit treatment, would at once clearly demonstrate the claims of the Perlit process. The writer has constantly pointed out the necessity for this simple and direct comparison. This has not yet been published so far as the writer is aware.

The Perlit Method.

The only authoritative information publicly available is that contained in the various patent specifications. It is of some interest to study the details of the information given in the original Diefenthaler patent (British patent No. 147,933). From this patent specification we may infer that the Perlit conditions are obtained by casting suitable irons into moulds preheated to certain suitable temperatures. Two examples are given in detail, and the conditions of composition, casting thickness, and mould temperature are specified as follows:—

	Composition Per cent.	Casting thickness.	Mould temp.
Example (1)	Tot. C. 3.00	—	—
	Si 1.00	10 mms.	390°F.
	Mn 0.70	20 ,,	300°F.
	S. 0.10	30 ,,	210°F.
	P. 0.40	—	—
Example (2)	Tot. C. 2.80	—	—
	Si 0.80	10 mms.	470°F.
	Mn —	20 ,,	380°F.
	S. —	30 ,,	290°F.
	P. —	—	—

* See F.T.J., October 16, 1924.
† See H. J. Young, F.T.J., August 20, 1925.

It is stated that "it is a comparatively simple matter to prepare scales or curves for a particular composition from which without further trouble the necessary temperature of the mould can be read for a particular thickness of material."

This is not such a simple matter as the above statement would lead one to believe. In comparing the composition of the two examples we may legitimately assume that the manganese, sulphur, and phosphorus contents are intended to be identical in both cases. In addition to the variation in silicon percentage, we also find a variation in the total carbon percentage. Strictly speaking, this prevents a direct comparison between these two cases. Putting this on one side, we may proceed to plot curves showing the relation between the casting thickness and mould temperature as indicated by the two examples. The curves obtained are shown in Fig. 1, and are found to be straight lines which have been continued in the figure to intersect both the zero ordinate and the abscissa.

If the statement in the text of the patent specification amounts to anything, it means that it is legitimate to use both interpolation and extrapolation as a means of determining the mould temperatures for other casting thicknesses from these curves.

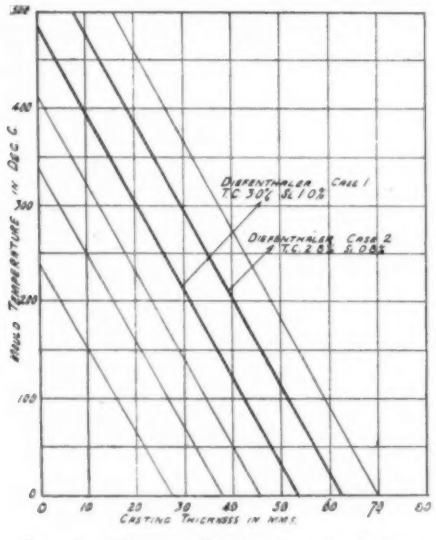


FIG. 1.—CASTING THICKNESS AND MOULD TEMPERATURE CURVE.

It is remembered that the two curves represent compositions varying in total carbon in addition to silicon, but in what follows it is assumed that the silicon is the principal constituent to be considered. For irons of silicon contents differing from the two examples plotted, extrapolation in a direction normal to these two curves is hardly justified. At the same time it is perfectly legitimate to assume that the curves for other silicon contents will lie in close proximity and remain parallel to these curves. A series of additional curves have been drawn in Fig. 1 parallel to the plotted results, and may be taken as representing the conditions of mould temperature and casting thickness for irons of silicon contents differing from the plotted results. The curves on the lower side and those on the higher side of the plotted results represent higher and lower silicon contents respectively.

Any point on these curves represents the conditions of casting thickness and mould temperature which produces Perlit iron for the given composition represented by the curve. This is apparently the claim of Diefenthaler. Then it folows that these curves represent the conditions of mould temperature and casting thickness at which with the particular composition the structural constitution of the iron is constant (*i.e.*, all pearlite). It can be said at once that there is no *à priori* reason for this assumption, and, in fact, there is every *à priori* reason against this assumption. We assume, however, that this has been established by experiment. In any event, interpolation between the plotted points on any one curve and extrapolation outside the range of the plotted points may be assumed to indicate the other conditions at which the constant Perlit type of structure is obtained.

Perlit Iron without Heating the Moulds.

Thus, obviously, the Diefenthaler curves indicate that the Perlit structure and conditions can be obtained without any mould heating whatever. Extrapolation of the points at which the curves intersect the zero abscissa represent the conditions of mould thickness and temperature at which the constant Perlit type of structure is obtained. Assuming zero temperature to be the normal temperature, the points of intersection of the curves with the zero temperature axis represent those compositions and particular casting thicknesses at normal temperatures without any preheating at which the constant Perlit structure is obtained.

Translating this into numerical results in the case of the two examples plotted from the patent specification, we find that Perlit conditions are obtained in the case of examples 1 and 2 with moulds at normal temperatures with casting thicknesses of 53 mms. and 62.5 mms. respectively. Similarly other compositions can be obtained as exemplified by the additional curves shown in Fig. 1, in which the composition can be adjusted for other thicknesses and so obtain the Perlit condition.

It is a clear interpretation of the curves constructed on the basis of the original Diefenthaler patent that irons can be produced which, with moulds at normal temperatures, will possess the uniform Perlit structure in various thicknesses of castings. It has never been made clear by the Perlit authorities whether or not the properties of all cast irons having the Perlit structure produced under the conditions are identical. Nor has it been claimed that the properties of an iron of a particular composition, in castings of different thicknesses, which by virtue of being cast under the conditions of the Perlit process, possess the uniform Perlit structure, are identical. There is, of course, no reason to suppose that the properties will be identical under either of the abovementioned circumstances. Whilst we are entitled to interpret the text of the patent specification in the manner that all the alloys falling on these curves comply with the requirements of the Perlit process, the utmost meaning that can be attached to this is that the alloys will have the pearlitic structure.

It is important to bear in mind that the terms of the patent specification do not attach any other special significance to the mould temperature beyond the relation already discussed. From a consideration of the curves constructed from the data given in the Diefenthaler patent specification we may conclude that cast irons can be obtained in varying thicknesses by casting in moulds at normal temperatures which comply with the requirements of Perlit iron. Whether these will have properties identical with irons complying with the requirements of Perlit iron but cast in moulds at higher temperatures is not disclosed.

Foundrymen and metallurgists will at once perceive that this normal temperature extension of the Perlit process is no different in principle from the ordinary method of composition control which has been in practice for many years

Criticism of Diefenthaler Curves.

The above has been based on the assumption that the data from which the curves have been drawn are taken from Diefenthaler's patent are correct. It is, of course, natural to assume that this data has been obtained by direct experiment. The fact that the relation between the casting thickness and the mould temperature is a simple linear relationship giving a straight line curve and the fact that the curves for the two examples differing in silicon and total carbon contents are strictly parallel throw considerable doubt on the reliability of the curves.

It is obviously absurd that the prolongation of the curves should cut the zero ordinate, and reason demands that they should be at least asymptotic to this axis. From other considerations the curves would be expected to be logarithmic in character if such a relationship is capable of graphical expression at all. Such curves would also be expected to cut the axis of normal tempera-

ture and would be continued downwards towards the abscissa of absolute zero temperature. The curves would, therefore, by reason of their cutting the axis of normal temperature, indicate that the Perlit conditions could be obtained without the necessity for heating the mould as already pointed out, but their altered character would affect very considerably the numerical accuracy of the data on which the process is operated.

A consideration of the extension of the Diefenthaler curves in this manner clearly shows that the Perlit conditions can be obtained using moulds at normal temperatures. Under these circumstances it would not appear likely that the Perlit conditions of structure or properties would differ materially from casting having a pearlitic structure of the ordinary type. Whether the Perlit conditions obtained using hot moulds are in any way different still remains to be considered, and the writer proposes to discuss this in a later section of these notes.

The Selling of Castings.—XXV.

By VOYAGEUR.

Trade Exhibitions.

Every now and again the founder will be invited to exhibit his castings at one or other or all of the exhibitions held in different parts of the country, or of the world. He must be very careful before he agrees to do so. He should examine the suggestion as carefully as if it were an invitation to take advertising space in a particular publication. At the same time, it must be remembered that there are differences between taking space at exhibitions and taking space in technical journals. Exhibitions, unless highly technical and limited in scope, always attract a large number of mere sightseers. These are equivalent to "waste circulation" in a journal. But whereas the fact that a large number of the people who read a technical journal may have no interest in the castings of the particular manufacturer advertising them, does not prevent those who are interested from reading the advertisement if they desire to do so, the presence of a large number of sightseers at an exhibition does hinder serious business people from examining one's stand in the comfort they desire. Crowds invariably hamper and irritate.

The lesson to be drawn from this is that the more popular in character the exhibition the less likely is it to bring trade to the founder whose castings are of technical interest only. Of course, if he makes castings that appeal to the general public, he will welcome popularity in an exhibition, but it is fairly safe to say that the majority of founders cater for technical rather than general buyers.

Broadly speaking, it pays the founder to exhibit his goods to the public at organised fairs or exhibitions if the fair is specialised rather than general in character, and if he has something novel or new to show. Buyers and engineers go to exhibitions not to see the old products with which they have been familiar since their youth, but to see the very latest developments in this, that, and the other direction. For example, a man will look at a casting of stainless steel, whereas a casting of ordinary steel for the same purpose might not interest him in the least.

If, therefore, the manufacturer feels that he has something striking and new to exhibit; if he feels convinced that the exhibition is likely to be attended by the sort of people who have business to place; then it will pay him to take space. But having taken it, he must use it to the best advantage.

First and foremost in this adequate employment of dearly-bought space is the design of the stand itself. It is not always easy to obtain in advance from the organisers of exhibitions a plan of the hall as it actually will appear; but it can be done, and should be insisted upon. When this plan is in the founder's possession he should study it in order to obtain from it necessary information on the following matters:—(1) How the stand he has bought is situated in relation to the various entrances and exits? (2) Which way the majority of people will go as they pass his stand? (3) How the stand is fixed in regard to adequate light during the day? (4) How it is situated in relation to the electric or other lamps at night? (5) How wide is the gangway along which people must pass as they go by his stand? (6) Will people pass his stand in a steady stream all day or intermittently? If the latter, why, and at what periods?

It is desirable to indicate the importance of each of these questions separately in order that it may be understood:

(1) The position of the stand in regard to entrances and exits reveals not only the frequency with which it will be passed by visitors, but also their mood as they pass. Stands near the main entrance, for example, will be seen by people at their very freshest, before they have had time to weary. Facts of this sort are valuable to the designer.

(2) The main flow of people past the stand is a thing the designer needs to know, so that he may dispose his attention-arresting devices in the most effective way.

(3) and (4) This information gives the exhibitor an idea of how to place his exhibits in order to get the most light upon them, and enables him to estimate how much additional light he will need to provide at his own expense. It also helps him to decide whether to put his main display in the foreground or in the background, and whether his arrangement will suffice for both day and evening, or must be changed for the one or the other.

(5) This information is of great value. Narrow gangways mean congestion, with all the concomitant pushing, jostling, irritation and limitation of display-value. The narrower the gangway the higher will the founder have to raise the main elements of his display, so that instead of having to push and scramble to the railing of his stand in order to see what he is showing they can, whether on one side of the gangway or the other, see by looking upwards something of his message and his goods.

(6) The design of the stand will be largely influenced by the constancy or otherwise of the flow of visitors past it. The nearer it stands to the principal entrance, for example, the brisker and more constant will the flow be, either inwards in the morning or outwards at night. If necessary, a rearrangement of the main elements of the stand's design may be made during the less busy periods, so that the outward flow at night is again caught and held by the display. Again, the stand may not be near an entrance or exit, but may neighbour a restaurant. Obviously, at certain readily calculable times there will be a flow of visitors pass the stand towards the restaurant. This, again, will influence the design.

The information under these six heads having been secured, or as much of it as possible, the founder must then turn his attention to the practical aspects of stand-designing. His best plan will be to make a wooden model of his stand and superimpose upon this facsimile reproductions of his exhibits and display-elements. This will give him some idea of the eventual appearance. Everything should, of course, be strictly to scale. He may prefer to entrust the work to a professional stand-designer; but he will be better advised to let his works engineering department and publicity department between them make all the necessary arrangements. The reason is that the really good stand-fitters get so much work to do at exhibition times that they are unable to cope with it. Delays then take place, and the final details, instead of being carefully planned and executed, are rushed through hastily so as to be in time for the opening date. Again, one great advantage to be secured by the founder, if possible, is early arrival on the site. This means that he can dump his packing cases and rubbish on the site of other people's stands, not occupied at the moment, and proceed carefully and methodically with the erection of his stand. If he arrives late he finds all the other stands in position, and he has to do all his work within his own cramped space. No one will allow him to dump anything out of his way on to another site. Cranes, labourers, and so forth, will all be busy, and difficult to secure. In short, early arrival on the spot—which can usually be secured when the designing is done at the founder's own works—means all the difference between erection in comfort and erection under difficulties.

Ryland's Directory, 1926.

RYLAND'S COAL, IRON, STEEL, TINPLATE, METAL, ENGINEERING, HARDWARE AND ALLIED TRADES' DIRECTORY, 1926.—London: Eagland & Company, Limited, Bessemer House, Adelphi, W.C.2. (Price: Bound in morocco, £2 12s.; in cloth, £2 2s. net.)

The 1926 (eighteenth) edition of this well-known standard reference book, just published, contains over 2,200 pages, or about 100 more than the previous issue. It now includes Ryland's List of Merchant Exporters and also Ryland's Directory of Ironmongers, formerly published separately. After a short Preface explaining the scope of the directory, there follow several helpful indexes (of towns, telegraphic addresses, brands, trade marks, trade names and others). The alphabetical section, extending to over 750 pages, contains not only the names of manufacturers and merchants in the trades enumerated on the title page, but also the subscribed capital, names of directors, partners, class of manufactures, etc. The geographical section, which follows next, gives a list of firms classified according to counties and towns and extends to nearly 300 pages. "Trades Classified," the section which comes next and extends to nearly 600 pages, comprises:—(1) A list of colliery owners, with name index to their collieries, of coke makers, gasworks, electric power stations, by-product manufacturers, and patent fuel makers; (2) a list of iron-mine owners, with a name index to the mines, of iron-ore importers and merchants; (3) limestone quarries; (4) consulting and manufacturing engineers; (5) a machinery section, for which it is claimed that it is by far the most accurate list of the kind hitherto published. A list of special trade names adopted by the various firms for their engineering specialities will be found in the trade-mark section; (6) iron, steel, brass and aluminium founders; (7) founders' specialities, with classified list of their castings in alphabetical order from agricultural machinery castings to waterworks castings; (8) a refractory section, with lists of sand quarries, silica brick makers, etc.; (9) a metal section, which includes the non-ferrous metals, with lists of the various mine-owners, smelters, etc., down to the makers of finished products; (10) a heavy-hardware section, which includes many specialities; (11) lists of wholesale and retail ironmongers; (12) a list of merchants, stating, as usual, whether they are iron and steel, tinplate or metal merchants or agents, and in many cases their specialities. Separate lists are given of merchants who stock iron and steel bars, shapes, etc., and of scrap-metal merchants.

There is incorporated, in addition to the usual list of British ferrous and non-ferrous foundries, a list of South African, Australian, and Indian foundries. The foundry equipment section has been brought thoroughly up to date, and foundrymen desiring to know the suppliers of any type of machine or raw material can rely upon having access to a complete list.

The lists in the iron and steel section include:—(1) Pig-iron producers, with the brands of pig-iron made, and producers of ferro-alloys, with analyses of the various brands of pig-iron, ferro-alloys, etc.; (2) steelworks producing steel by the Bessemer and/or open-hearth process, with the number and sizes of their furnaces, etc.; (3) a complete list of makers of steel by the electric process, also with the number and sizes of furnaces; (4) a list of brands of finished iron now being made; (5) separate list of mills rolling iron and steel, with details of plant; (6) tinplate makers, with list of brands, the number of mills, etc.

The classified list of makers of sections gives under the different headings, from angles to zeds, the names and addresses of those who roll shapes in iron or steel, or both. It is claimed for this that it is the most complete list of its kind published either in this or in any other country, with particulars as to the actual sizes of every description of iron or steel rolled, the usual margins allowed as regards width, thickness, length, weight, etc., and the purposes for which shapes, hoops, strip, rails, plates, sheets, etc., are intended.

The Merchant Exporters' Section contains a comprehensive list of firms who buy iron, steel, tinplate, metals, machinery and hardware for export. A separate list is given of the principal coal merchants, factors and exporters. In this connection each firm alphabetically listed carries a number which is largely used by merchants doing an international business as a telegraphic reference. This numbering system has been extended to take in all the important foreign and dominion metallurgical firms.

As regards the British colonies and foreign countries, a comprehensive directory is given of the principal makers of pig-iron, steel, and puddled iron of the world and of rolling mills abroad, in many cases with particulars of the number of furnaces, converters, etc. There is also a list of foreign collieries.

Finally, there is a long list of employers' associations, trade unions, conciliation boards, joint standing industrial councils, research associations, etc., and a list of newspapers and periodicals published in connection with the trades represented in the Directory.

There are also maps; a large folding map of the railways of Great Britain, and smaller maps of the various British coalfields, the Saar district, of the iron and steelworks in Lorraine and Luxemburg, the Krivoy Rog iron-mining district, etc.

As will be seen, Ryland's Directory is a remarkable business book, and will be found a great help in every office connected with the trades represented in the volume.

Contracts Open.

Belfast, February 10.—Iron and steel, etc., for twelve months from March 1, for the Belfast and Co. Down Railway Company. Mr. H. E. Mellor, secretary, Queen's Quay Terminus, Belfast.

Bloemfontein, March 11.—Steel, etc., for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 2771.)

Burnley, February 8.—Cast-iron socket and spigot pipes, during the next six months, for the Gas Department of the Corporation of Burnley. Mr. J. H. Clegg, engineer and manager, Gas Works, Parker Lane, Burnley.

Cape Town, February 25.—Cranes, for the South African Railways and Harbours. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 2,747.)

Johannesburg, February 25.—Bronze bars, etc., for the South African Railways and Harbours. The Department of Overseas Trade (Room 48), 35, Old Queen Street, London, S.W.1. (Ref. A.X. 2769.)

Liverpool, March 17.—Iron and steel, etc., for period of twelve months ending March 31, 1927, for the Corporation. The City Engineer, Municipal Buildings, Dale Street, Liverpool.

London, E.C., February 8.—Iron and steel, etc., for 12 months commencing April 1, for the M.W.B. The Chief Engineer, Metropolitan Water Board, 173, Rosebery Avenue, London, E.C.1.

London, W.6, February 10.—Iron and steel, etc., for 12 months commencing April 1, for the Hammersmith B.C. Mr. F. Hill, borough electrical engineer, 85, Fulham Palace Road, London, W.6. (Fee 2s. 6d.).

Patent Specifications Accepted.

The following list of patent specifications accepted have been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full specification can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each.

29,409. CRAVEN, J. M. F. Rolling of metals. (July 4, 1924.)

15,692. SEAL COMPANY (LONDON), LIMITED, JASCOURT, I., PATTINSON, H. D., and ROSE, J. Electrolytic process for the removal of rust and scale from metals. (March 30, 1925.)

21,756. WUST, F. Process for the production of tin from alloys containing iron. (September 15, 1924.)

24,287. TOURNIE, R. H. M. L. Process for the direct production of iron and steel. October 13, 1924.

10,849. MULLER, O. Foundry moulding-machines. (April 26, 1924.)

24,657. HALL, L. Metal-melting furnaces. (December 24, 1924). (Divided Application on 244,915.)

26,113. MEYERHOFER, A. F. Process of producing metal compounds. (December 20, 1923.) (Divided Application on 226,491. Addition to 226,491.)

22,049. TAFEL, W. Processes for the deoxidation of ingot iron and steel. September 18, 1924.

The Birth of the Puddling Industry.

By T. B. F.

The claim that the inventor of the puddling process was Mr. Joseph Hall, of the firm of Messrs. Barrows & Hall, of the Bloomfields Ironworks, Tipton, has been disputed. It is true that Mr. John Dawes made experiments on the same lines and with results similar to those achieved by Mr. Hall. In this connection Mr. John Gibbins published a statement in which he said: —

"Recently a patent has been taken out for an elaborate mode of burning tap-cinder in kilns. I can readily believe that its quality or power of resisting heat may be improved thereby, but I have not thought it necessary to alter my old method of burning it in open heaps just like ironstone. In this way, mixed with the other materials, or alone, it will be found to do very well."

Against this we have the testimony of Mr. John Percy, M.D., F.R.S., author of "Metallurgy" and lecturer on metallurgy at the Royal School of Mines. Mr. Percy, who knew Mr. Hall personally, says "he was undoubtedly one of the most experienced and skilful producers of wrought iron in Staffordshire, and no firm in that county has enjoyed a higher reputation for the quality of its manufactured iron, for example, boiler plates, than Bradley, Barrows & Hall."

Mr. Hall himself, in a letter which he addressed to the editor of the then "Birmingham Journal," under the title of "Iron Scrap, or the Issue of an Old Shoe Heel," gave an account of a long-continued series of experiments in re-melting and extracting from the scrap slag of puddling furnaces a quantity of ductile iron. These experiments, he explained, led to the introduction of pig-iron and the boiling system into the puddling furnace. This must have taken place about 1830, and the fact constitutes the strongest presumptive proof that Mr. Hall was the first to introduce the system of boiling, which, as Mr. William Fairbairn points out, "ultimately dispensed with the refinery, and established the more expeditious process of puddling direct from the pig."

In a volume which he published five years before his death, Mr. Hall carried the vindication of his claim a point farther. He emphasised three important considerations. The first was that he was accidentally led to the process of the substitution of cinder for sand upon the plates for the puddling-furnace bottoms by attempts to save and work up the residue, rich in iron, of forges, such as the contents of puddlers' boshes. Secondly, he devised an improved construction of iron bottoms, consisting of a frame of plates united one to another all round the inside of the furnace, of a height of about 15 or 16 in., with a projection of fire-brick hanging over the top of the plates, an idea which he informs us was "the result of years of brain work and of incessant thought by night and by day. Thirdly and finally, he definitely disposes of all doubt as to the part which he personally played in the application of roasted tap-cinder or "bull-dog" to puddling. So far from reaping any personal reward for his discoveries, it is related that he met only with discouragements where he might reasonably have expected, as he was clearly entitled to, the warmest support.

When he mentioned the project for the improvement of the furnace bottom to one practical man he was laughed at for his pains and that that it was not only impossible, but ridiculous.

Mr. Hall stoutly insisted upon the indefensibility of the process of dry pig puddling, and he enthusiastically praised the work of Homfray, who is reputed to have introduced the process of refining. But though his own experimental work and researches were met with some degree of early scepticism and doubt, their merit was such that they commended themselves to the active and enterprising leaders of the industry who knew "good things" when they saw them. Hall's process came to be almost exclusively used in the manufacture of wrought iron by puddling.

But excellent though the products of the firm with which he was associated were, nothing could save the works from the melancholy fate which befel so many famous ironworks when the worst of all "black" times came to the great industries of the Black Country. In the heyday of their prosperity Messrs. Barrows & Hall had ne less than 100 puddling furnaces at work, quite the largest number of any ironworks in South Staffordshire, and they produced 1,000 tons of finished iron per week. To-day these huge works are memories only. They were dismantled long ago, in common with many hundred others of the blast and puddling furnaces which thickly dotted the whole area of the Black Country between Birmingham and Wolverhampton.

Mr. Hall did not live to see the decline of an industry which he helped so much to build up. He died in 1862, at the age of 72.

Book Reviews.

The Physical Chemistry of Steel Making Processes, a General Discussion held by the Faraday Society and the Iron and Steel Institute. Published by the Faraday Society, 90, Great Russell Street, London, W.C.1. Price 8s. 6d. net.

This book should certainly be obtained by everybody in charge of steel-making processes, as it contains the latest expressions by the highest authorities on subjects of basic importance to the prosecution of metallurgical science. Sir Robert Hadfield, in his Paper on "Physical Chemistry in Steel Making," outlines past work, the present position and the problems of the future so far as they concern steel-making.

The second Paper, "Balanced Reactions in Steel Manufacture," by Dr. M'Cance, we consider the best of an excellent collection, and his conclusions disclose probably what will be generally accepted as representing the true reactions of steel manufacture. Mr. T. P. Colclough's Paper on "A Study of the Reactions of the Basic Open-Hearth Furnace," provides a number of tables taken from works practice, which he uses to enlarge upon his postulated equations.

In re-reading Mr. Frank T. Sisco's Paper on "The Chemical Reactions of Basic Electric Process," we felt that although meetings of this character are held from time to time an enormous quantity of data, which ought to be presented by way of discussion, is held back for reasons of pure laziness on the part of members. This particular Paper brought it to our mind because in a large number of private analyses of electric-furnace slags none corresponds with the authors, but possess similar indefiniteness, which perhaps the study of large numbers could remove.

"Slag Reactions," by Peter M. MacNair; "Equilibria in Systems Involving Ferrous Oxide," by Professor J. B. Ferguson; "The Function of Ferric Oxide in Acid or Basic Open-Hearth Furnaces," by J. H. Whiteley; and "Physico-Chemical Phenomena from Melt to Ingot," by Alexander L. Feild, are all Papers of definite practical interest. A Paper coming into a slightly different category is Mr. W. J. Rees' contribution on the "Micro-Examination of Steel Making Refractories." It is, however, of equal excellence in its own department.

A fair proportion of the discussion, especially that contributed in writing, is of real interest. There is a reduction in price to members of the organising societies.

Mechanical World Electrical Pocket Book, 1926. Published by Emmott & Company, Limited, 20, Bedford Street, London, W.C.2. Price 1s. 6d. net.

This much-appreciated little book has been made more useful for the foundryman by the inclusion of new sections related to his work. Jointing conductors is a subject of interest to those in charge of electric furnaces, as the losses from this cause are heavier than most people imagine. Again, the industrial application of electro-chemistry is another subject which interests many foundrymen: whilst cutting by the electric arc is regularly practised by steel castings manufacturers. However, the main job for a work of this character is to supply data of a reliable character for calculations, and in this it succeeds.

XUM

Trade Talk.

THE BIRCHILL'S FURNACES, LIMITED, are dismantling their two furnaces at Walsall.

MR. JUSTICE EVE, in the Chancery Division, on January 26, confirmed the reduction of capital proposed by Vickers, Limited.

THE HOLBECK ENGINEERING COMPANY have removed from 34, Norfolk Street, Strand, London, W.C.2, to Central House, Kingsway, W.C.2.

KITSON & COMPANY, LIMITED, Airedale Foundry, Leeds, have just received an order for four locomotives of the special Kitson-Meyer articulated type, for the Girardot Railway of Columbia.

PROFESSOR T. TURNER gave his annual presidential address to the Birmingham University Metallurgical Society at the Edgbaston buildings on January 26, his subject being "Some Recent Metallurgical Research."

DR. J. T. DUNN presided at a meeting of the Newcastle Section of the Institute of Chemistry, held at the Armstrong College, on January 20, when Dr. J. A. Smythe lectured on the "Crystallisation of Metals and Alloys."

HALL & PICKLES, LIMITED, Port Street, Manchester, have been added to the Admiralty, War Office and Air Ministry's lists of tool steel contractors. The company's works are in Arundel Street, Sheffield, and are known as the Hydra Crucible Steel Works.

THE STAFF AND WORKPEOPLE of the Villiers Engineering Company, Limited, Wolverhampton, recently gave a complimentary dinner to Sir Charles Marston, their governing director, in celebration of the honour of knighthood conferred upon him at the beginning of the present year.

DARBY & COMPANY, Navigation Street, Birmingham, have issued a chart in colours of Scotch, Derby and Northants No. 3 foundry pig-iron prices, net at furnaces, over the last seven years. Such important factors as the decontrol of the industry, the coal strike, the French entry into the Ruhr, etc., are clearly indicated, and a comparison with pre-war prices is secured at a glance.

DR. C. M. WALTER (Industrial Research Laboratory, Birmingham) read a paper on January 21 before the Birmingham and Midland Drop Forgers' Association on the application of gas, particularly in relation to furnaces; and Mr. John Fallon (West Bromwich) also discussed the subject of "Furnaces" before the members of the Midland Junior Gas Association on the same evening at the Birmingham Council House.

INTIMATION HAS BEEN MADE to Mr. J. C. Bishop and Mr. O. Coyle, joint secretaries of the Board of Conciliation for the Regulation of Wages in the Pig-iron Trade of Scotland, that the accountants have examined the employers' books for October, November and December, and certify that the average net selling price is £4 0s. 9d. per ton. This means that there will be a reduction in the wages of the workmen of 3 per cent. on the basis rates.

THE ORDERS for the 33,000 tons of steel rails required by the London and North-Eastern Railway Company have been placed with the following firms: W. Beardmore & Company, Limited, Glasgow; Steel Company of Scotland, Limited, Glasgow; Barrow Hematite Steel Company, Limited, Barrow-in-Furness; Cargo Fleet Iron Company, Limited, Middlesbrough; Bolckow, Vaughan & Company, Limited, Middlesbrough; Cammell, Laird & Company, Limited, Sheffield; Steel, Peech & Tozer, Limited, Sheffield; S. Fox & Company, Limited, Stocksbridge, near Sheffield; Partington Iron and Steel Company, Limited, Manchester.

BOTH IN respect of the number of companies and the amount of their capital, company registrations in 1925 show an increase over those effected during the preceding year, and it is interesting to observe that the increase in both respects is in the "public" company section, according to the annual statistical report of Jordan & Sons, Limited. A classification of the businesses concerned show the leading groups:—Engineers (489), mines (257). The highest aggregate capitals include:—Mines (£11,028,939), engineers (£3,766,475). Iron and brass companies number 208, with capital totalling £1,744,057.

THE CLEVELAND IRONMASTERS' ASSOCIATION has addressed a letter to the Middlesbrough General Purposes Committee commenting upon the disparity between the wages paid to municipal employees and other sheltered workers and those which competitive industry could afford to the productive worker. Emphasis was laid on the fact that industry, despite the grave position with which it was faced, could not draw upon the ratepayers to subsidise the wages of workmen. Employers and workers in the staple industries had made great sacrifices in order to keep the works going; the employers by operating not only without profit but often at a loss, and the workers by accepting reductions in wages. It was therefore requested that, in discussing wage questions, the Council should bear in mind the burden imposed upon industry by municipal expenditure.

Company Reports.

William Asquith, Limited.—Interim dividend, 8 per cent. per annum on preference shares.

Westinghouse Brake & Saxby Signal Company, Limited.—Dividend, 6 per cent., less tax, for year.

John Shaw & Sons (Wolverhampton), Limited.—Net profit, £28,503; brought forward, £29,008; dividend, 7½ per cent., less tax; carried forward, £42,192.

Ferguson Pailin, Limited.—Net profit, £37,383; brought forward, £24,614; dividend, 9 per cent. per annum for second half-year on preference shares (making 8 per cent. for year); dividend, 19 per cent. per annum on ordinary shares (making 13 per cent.); reserve, £10,000; writing off goodwill and patents, £1,214; carry forward, £35,231.

Obituary.

MR. O. HOWELL, Parkhurst Fields, Park Road, Newport, a director of T. H. Howell, Limited, iron and steel merchants, died recently.

MR. WILLIAM MACKIE, managing director of A. & W. Smith & Company, Limited, Eglington Engine Works, Glasgow, died on January 24, at his residence at Newlands, after an illness lasting several months. He entered the company's service in 1907 as general manager, and in 1917 was elected managing director.

MR. WILLIAM WHITFIELD, of Rotherham, died recently, aged 57 years. After reading for law, he identified himself with steel manufacturing. He had been connected with the firm of William Oxley & Company, Parkgate Steel Works, since 1887, and in 1903 he became a director and the London representative of the firm.

New Companies.

Arthur E. Ames, Limited, 17A, Dale End, Birmingham.—Capital £500 in £1 shares. Engineers' tool makers. Directors: A. E. Ames, H. Ames and A. Ames.

Dorman Long Trust Association, Limited, Zetland Road, Middlesbrough.—No capital. Secretary, H. V. Roxby.

Collins & Avery, Limited.—Capital £400 in £1 shares. Engineers.

Engineering Trader, Limited, 26, Holborn Viaduct, London, E.C.1.—Capital £3,000 in 2,000 10 per cent. cumulative preference and 1,000 ordinary shares of £1. Directors: T. Allsop, H. Mase and S. P. Clough.

Expert Die Castings (1926), Limited, 417, Old Ford Road, London, E.—Capital £12,000 in 16,000 ordinary shares of 5s. each and 8,000 preference shares of £1 each. Directors: H. W. Hollands, E. A. Hollands, J. R. Trudgett, and F. T. Davenport.

G. E. T. Smithson & Company, Limited, 31, Side, Newcastle-on-Tyne.—Capital £10,000 in £1 shares. Metal merchants.

George Easdon & Company, Limited, 13, Bath Street, Glasgow, C.2.—Capital £2,000 in £1 shares. Brassfounders. Directors: G. Easdon, junr., and C. C. Millar.

Lambert Heater and Engineering Company, Limited, 112a, High Street, Harlesden, London, N.W.10.—Capital £2,500 in £1 shares.

Midland Bright Drawn Steel and Engineering Company, Limited, 267-8, Castle Street, Dudley.—Capital £10,000 in £1 shares. Directors: H. Hipkiss and J. Gough.

Pickford, Evans & Company, Limited, 262, Ecclesall Road, Sheffield.—Capital £2,000 in £1 shares. Manufacturers of engineers' and small tools. Directors: J. H. Pickford (chairman) and E. H. Pickford.

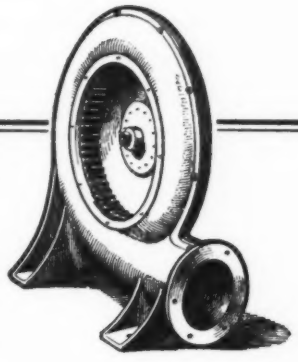
Samuel Brookes & Sons, Limited, Tube Works, Sedgley, Staffs.—Capital £3,000 in £1 shares. Irontube manufacturers. Directors: S. Brookes, sen., S. Brookes, jun., and H. Brookes.

Steel & Tool Industries, Limited, 146, Bishopsgate, London, E.C.2.—Capital £505 in 500 10 per cent. cum. pref. shares of £1 and 100 ordinary shares of 1s. Directors: W. R. Starkie and C. T. W. Goddard.

Staffordshire Iron and Steel Company, Limited, Mill Street, Brierley Hill, Staffs.—Capital £5,000 in £1 shares. Directors: H. Segar and Beatrice I. Share.

The Marine Oil Engine Development Syndicate, Abbey House, Victoria Street, London, S.W.1.—Capital £25,000 in £1 shares. Directors: Vice-Admiral Sir George G. Goodwin, K.C.B., E. W. Harvey, R. I. Dodsworth and G. Clark. Secretary, H. Barnes.

William Jones, Clifton, & Company, Limited, 1 and 3, Silver Street, New Oxford Street, London, W.C.1.—Capital £10,000 in £1 shares. Die sinkers.



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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—The position in Cleveland has, if anything, gained additional strength during the past week, the home demand for foundry iron having further developed to the extent of entirely absorbing current furnace outputs, while makers, already fully booked for months ahead, have, therefore, no great inducement to increase production and run the risk of an enforced stoppage through a coal strike. Consumers, on the other hand, have hitherto been reluctant to believe that advanced prices were to any extent probable, and have, in consequence, been caught short, with the result that sales are now being freely effected for delivery up till next June, and beyond that date at prices some 6s. per ton higher than could have been obtained without difficulty last October. The amount of prompt iron to be had is quite negligible. Quotations, therefore, remain firm, with f.o.b. export prices as follow, home figures being 6d. per ton less: No. 1, 73s.; No. 3 G.M.B., 70s. 6d.; No. 4 foundry, 69s. 6d.; and No. 4 forge, 68s. 6d. per ton.

The hematite market on Tees-side also continues exceptionally strong. Prompt iron is unobtainable, and practically the whole output is taken up as soon as it leaves the furnaces, but a limited amount of business is being taken, with the option of February-March delivery, at 77s. 6d. per ton for mixed numbers. Producers are well booked ahead, and up to 80s. per ton is asked for business further forward. The No. 1 quality is 78s. per ton. In Cumberland and North Lancashire there has been some slackening of demand, but there has been little change in prices, quotations for Bessemer mixed numbers ruling £4 2s. 6d., c.i.f. Welsh ports; £4 5s. to £4 7s. 6d. delivered Glasgow; £4 10s. delivered at Sheffield; and £4 13s. 6d. per ton delivered at Birmingham.

THE MIDLANDS.—At Birmingham and other district markets the demand for foundry pig is fairly well maintained, but there is at present no disposition on the part of makers to alter the prices quoted last week; in fact, the movement is more likely to be directed upward, and some of the furnaces, Derbyshire particularly, are off the market for the time being. The buying movement during the first three weeks of the month has subsided, and purchases are now somewhat spasmodic. Ruling quotations are as follow: Derbyshire No. 3 foundry, 67s. 6d. to 68s.; Staffordshire No. 3 foundry, 67s. 6d. to 68s. 6d.; Northants, No. 3 foundry, 64s.

SCOTLAND.—In the markets for Scottish foundry pig demand continues on a disappointing scale, consumers only buying from hand to mouth, with very limited interest being taken in iron for export. The price, meanwhile, remains unchanged at 76s. 6d. per ton for No. 3 foundry at the furnaces. Continental foundry is only being offered to a limited extent, and the price current at Grangemouth is about 69s. There is no improvement in hematite, and the demand is still very poor. Prices are unchanged at 76s. for Scotch and 85s. for West Coast, delivered consumers' works.

Steel.

The position in the Sheffield steel market is evidencing more activity, and generally the outlook is encouraging. Home-produced basic billets are selling with slightly greater freedom, but the prices for soft, medium and hard qualities appear heavy by comparison with imported material. Sales of acid billets are on a more generous scale. Steel production is expanding, and acid steel is a very good feature at present. Big quantities of tool steel are being produced to meet a wide range of orders. Motor and tramway steels are two increasingly active sections. In the tinplate market inquiries of late have been on a fair scale, but the volume of business passing has not been extensive, the ruling quotation for standard quality ruling 19s. 3d. to 19s. 6d. per box, net cash, f.o.b. Bristol Channel ports.

Scrap.

Unstable conditions still characterise the scrap metal markets in most districts, consumers being apparently reluctant to enter into commitments on an extensive scale too far ahead. In South Wales, heavy cast-iron scrap in large pieces and furnace sizes has an improved demand, and is a little firmer at 63s. 6d. to 66s. Good machinery scrap in foundry sizes has a weak local demand at 67s. 6d. to 70s. At Birmingham market last week 70s. to 75s. per ton delivered is the maximum price offered by local works for the best quality heavy cast-iron scrap. There is a very poor demand for light cast-iron scrap at 60s. per ton delivered. In Scotland, machinery cast-iron scrap remains easier at 72s. 6d. to 73s. 6d. per ton, and ordinary qualities 4s. to 5s. per ton less, with light descriptions 59s. to 60s. per ton.

Metals.

Copper.—So far as the year has already passed it can hardly be said to have had much effect upon this section of the base metal markets, both the consuming and speculative interests continuing quiet and uneventful. At the same time, any signs of recovery would quickly stimulate activity, but at the moment there do not apear to be any factors in evidence capable of lifting the metal out of its present state of indifference. Unfortunately the same factors are at work keeping the metal down, viz., hand-to-mouth buying on the part of home consumers, the inability of Germany to take more metal, and the franc exchange. Current quotations:—*Cash*: Thursday, £58; Friday, £58; Monday, £58 10s.; Tuesday, £58 12s. 6d.; Wednesday, £59 5s.

Three Months: Thursday, £59; Friday, £59 2s. 6d.; Monday, £59 10s.; Tuesday, £59 15s.; Wednesday, £60 5s.

Tin.—Although tin values are again below the levels of the previous week, due to profit-taking sales and a quieter demand, there does not appear any serious apprehension of an impending collapse, and doubtless the forthcoming statistical returns may put a quite different complexion on the situation. Speculative interest is at a low ebb for the present, partly because of the expectation of considerably larger shipments from the Straits this month, but the view nevertheless continues to be expressed that a further depletion of the world's visible supplies is only a matter of time. Current quotations:—*Cash*: Thursday, £275 5s.; Friday, £274; Monday, £279 12s. 6d.; Tuesday, £279 5s.; Wednesday, £279 10s.

Three Months: Thursday, £271 10s.; Friday, £270 15s.; Monday, £274 10s.; Tuesday, £274 7s. 6d.; Wednesday, £275 5s.

Spelter.—Rather more activity has been in evidence in this metal of late, consumers having purchased on a freer scale, while there has also been some buying on speculative account. Holders have exercised little selling pressure, and only small quantities have been offered from Germany, whilst the floods on the Continent are reported to have seriously interfered with production at some of the works, which have been inundated. Current quotations: *Ordinary*: Thursday, £36 12s. 6d.; Friday, £36 17s. 6d.; Monday, £37 1s. 3d.; Tuesday, £37 2s. 6d.; Wednesday, £36 16s. 3d.

Lead.—In the market for soft foreign pig there has recently been some weakening of values under the increased accumulation of supplies in evidence, although this metal is held in private warehouse, and the surplus thus hanging over the market is guess work. Consumers are fully aware of the present artificial conditions, and are anything but eager to cover their needs. Current quotations:—*Soft foreign (prompt)*: Thursday, £34; Friday, £34 3s. 9d.; Monday, £34 8s. 9d.; Tuesday, £34 7s. 6d.; Wednesday, £34 2s. 6d.

MR. W. NEWSHAM, the Rex Brass and Iron Foundry, Edward Street Works, Lancaster, is paying a first and final dividend of 2s. 2d. in the £.

MOULDERS' WIRE PINS

H. W. VENTON,
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Telephone: City 4739.

"GLUTRIN" STANDS ALONE
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After twenty years Foundry Service
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Economise in production by using
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Full particulars from the following stockists:

MIDDLESBROUGH:
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LONDON:
Messrs. The Blackfriars Foundry Requisite Co., Ltd., 34 35, Norfolk Street, London, W.C.2.

GLASGOW:
Messrs. Albert Smith & Co., Foundry Engineers, etc., 60, St. Enoch Square, Glasgow.

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FALKIRK, CHESTERFIELD, BILSTON, MIDDLESBRO.

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WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	59	5	0
Three months	60	5	0
Electrolytic	65	15	0
Tough	61	10	0
Best selected	62	10	0
Sheets	90	0	0
India	75	0	0
Wire bars	65	15	0
Do. Feb.	65	7	6
Do. March	65	7	6
Ingot bars	65	7	6
H.C. wire rods	69	15	0
Off. av. cash, Jan.	59	1	6
Do., 3 mths. Jan.	60	3	0
Do., Sttlmnt, Jan.	59	1	7½
Do., Electro, Jan.	65	11	4½
Do., B.S., Jan.	63	16	10½
Aver. spot price copper, Jan.	59	1	6
Do., wire bars, Jan.	65	16	3

Solid drawn tubes 13d.
Brazed tubes 13d.
Wire 10d.

BRASS.

Solid drawn tubes 12d.
Brazed tubes 13½d.
Rods, drawn 11½d.
Rods, extd. or rlld. 7½d.
Sheets to 10 w.g 10½d.
Wire 10½d.
Rolled metal 9½d.
Yellow metal rods 7½d.
Do. 4 × 4 Squares 8d.
Do. 4 × 3 Sheets 8½d.

TIN.

Standard cash	279	10	0
Three months	275	5	0
English	277	10	0
Bars	280	0	0
Straits	281	5	0
Australian	280	0	0
Eastern	280	15	0
Banca	282	5	0
Off.aver. cash, Jan.	282	3	3
Do., 3 mths., Jan.	276	4	4½
Do., Sttlmt. Jan.	282	3	0
Aver. spot., Jan.	282	3	0

SPELTER.

Ordinary	36	16	3
Remelted	36	5	0
Hard	30	15	0
Electro 99.9	40	7	6
English	37	15	0
India	32	15	0
Zinc dust	45	0	0
Zinc ashes	15	10	0
Off. aver., Jan.	37	14	2⅝
Aver., spot, Jan.	38	1	2¼

LEAD.

Soft foreign ppt.	34	2	6
English	35	10	0
Off. average, Jan.	34	13	7½
Average spot, Jan.	34	15	6¾

ZINC SHEETS, &c.

Zinc sheets, English	45	0	0
Do. V.M. ex whf.	43	0	0
Rods	50	0	0
Boiler plates	44	0	0
Battery plates	43	10	0

ANTIMONY.

Special brands, Eng.	99	0	0
Chinese	92	0	0
Crude	62	0	0

QUICKSILVER.

Quicksilver 15 0 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon 25%	9	17	6
45/50%	12	2	6
75%	21	15	0

Ferro-vanadium— 35/40% .. .. 15/- lb. va.
Ferro-molybdenum— 70/75% c. free 6/- lb.
Ferro-titanium— 23/25% carbonless 1/- lb.
Ferro-phosphorus, 20/25%, £19 5 0
Ferro-tungsten— 80/85%,c.fr. 1/10½ lb. to 1/11
Tungsten metal powder— 98/99% .. ..2/1 to 2/2 lb.

Ferro-chrome—

2/4% car.	£34	5	0
4/6% car.	£23	0	0
6/8% car.	£22	10	0
8/10% car.	£22	0	0

Ferro-chrome—

Max. 2% car.	£40	10	0
Max. 1% car.	£46	15	0
Max.0.70%car.	£56	10	0

70%, carbonless 1/5½ lb.
Nickel—99%, cubes or pellets £172 to £175
Cobalt metal—98/99% 10/3 lb.
Aluminium 98/99% £123
Metallic Chromium— 96/98% .. 3/9 lb.

Ferro-manganese (net)—

76/80%, loose	£15	7	6
76/80%, packed	£16	7	6
76/80%, export	£15	5	0

Metallic manganese— 94/96%, carbonless 2/- lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten .. s. d. 2 6
Finished bars, 18% tungsten .. 3 0
Per lb. net, d/d buyers' works.
Extras—
Rounds and squares 3 in. and over .. 4d.lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Do. under ¼in. to ⅛ in. .. .. 1/- lb.
Flats, ½in.×¼in. to under 1 in.×⅛ in. 3d. lb.
Do. under ½in.×¼in. 1/- lb
Bevels of approved sizes and sections 6d. lb.
Bars cut to length 10% extra
Scrap from high-speed tool steel—
Scrap pieces .. .. 3d.
Turnings and swarf 1d.
Per lb. net, d/s steel makers' work

SCRAP.

South Wales—	£	s.	d.	£	s.	d.
Hvy. steel	3	7	6	3	10	0
Bundled steel & shrngs.	3	2	6	3	7	0
Mixed iron & steel	3	2	6	3	3	6
Heavy cast iron	3	3	6	3	6	0

Good machinery for foundries 3 7 6 to 3 10 0

Cleveland—			
Heavy steel	3	1	6
Steel turnings	2	5	0
Cast iron borings	2	5	0
Heavy forge	4	5	0
Bushelled scrap	3	10	0
Cast-iron scrap	3	5	6

Lancashire—			
Cast-iron scrap	3	12	6
Heavy wrought	3	7	6
Steel turnings	2	0	0

London — Merchants' buying prices delivered yard.

Copper (clean)	51	0	0
Brass (clean)	40	0	0
Lead (less usual draft)	31	0	0
Tea lead	27	0	0
Zinc	25	0	0
New aluminium cuttings	88	0	0
Braziery copper	46	0	0
Gunmetal	46	0	0
Hollow pewter	185	0	0
Shaped black pewter	143	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1	72/6
Foundry No. 3	70/-
Foundry No. 4	69/-
Forge No. 4	68/-
Hematite No. 1	78/-
Hematite M/Nos.	77/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/3
,, d/d Birm.	93/-
Midlands—	
Staffs common*	—
,, No. 4 forge	63/6
,, No. 3 foundry	68/-
Shrops. basic	70/-
,, Cold blast, ord.*	185/-
,, ,, roll iron*	190/-
* d/d Birmingham.	
Northants forge	56/-
,, fdry No. 3	64/-
Derbyshire forge	63/6
,, fdry. No. 3	68/-
,, basic	65/-
Scotland—	
Foundry No. 1	81/6
,, No. 3	76/6
Hem. M/Nos.	76/6
Sheffield (d/d district)—	
Derby forge	67/6
,, fdry. No. 3	72/-
Lincs. forge	67/6
,, fdry. No. 3	70/-
E.C. hematite	88/-
W.C. hematite	90/-
Lincs. (at furnaces)—	
Forge No. 4	61/6
Foundry No. 3	64/-
Basic	63/-
Lancashire (d/d eq. Man.)—	
Derby forge	71/-
,, fdry. No. 2	75/6
Northants foundry No. 3	76/9
Dalzell, No. 3	110/-
Summerlee, No. 3	94/-
Glengarnock, No. 3	94/-
Gartsherrie, No. 3	94/-
Monkland No. 3	94/-
Coltness, No. 3	94/-
Shotts, No. 3	94/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars(cr.)	11	5	0	12	10	0
Angles				11	10	0
Tees to 3 united ins.				12	0	0
Nut and bolt				10	15	0
Hoops	14	0	0	15	0	0
Marked bars (Staffs.) f.o.t.				14	0	0
Gas strip	12	10	0	12	15	0
Bolts and nuts ⅜ in. × 4 in.				16	15	0

Steel—						
Ship plates	7	7	6	7	17	6
Boiler plts.				11	10	0
Chequer plts. £9	5	to	9	15	0	
Angles £7	0	0	to	7	5	0
Tees £8	0	0	to	8	5	0
Channels£	6	12	6	to	7	2	6
Joists £7	0	0	to	7	5	0
Rounds and Squares 3 in. to 5½ ins.				8	0	0
Rounds under 3 in. to ⅜ in.				7	15	0
Flats, over 5 in. wide and up				8	10	0
Flats, 5in. to 1½in.				7	10	0
Rails, heavy				8	0	0
Fishplates				12	0	0
Hoops (Staffs.)				10	10	0
Black sheets, 24g.				11	5	0
Galv. cor. sheets, 24g.				16	12	6
Galv. fencing wire 8g. plain				14	0	0
Billets,soft £6	0	0	to	6	2	6
Billets, hard				8	2	6
Sheet bars	6	2	6	to	6	5	0
Tin bars d/d	6	2	6	to	6	5	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	3½
Rods	1	3
Tubes	1	8½
Castings	1	2

Delivery 3 cwt. free
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	24.26
No. 2 foundry, Valley	22.26
No. 2 foundry, Birm.	22.00
Basic	21.76
Bessemer	22.76
Malleable	22.26
Grey forge	21.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila.	2.22
Steel bars	2.00
Tank plates	1.85
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.50
Sheets, black, No. 28	3.35
Sheets, galv., No. 28	4.60
Sheets, blue an'l'd, 9 & 10	2.50
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry 32/6 to 37/6
,, furnace 20/- to 25/-
Durham & North.
,, foundry 30/- to 33/-
,, furnace 18/-
Other Districts, foundry 30/- to 33/-
,, ,, furnace (basis) 11/9

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	19/4½
,,	28×20, ,,	38/9
,,	20×10, ,,	28/7½
,,	18¾×14, ,,	20/3
C.W.	20×14, ,,	17/7½
,,	28×20, ,,	35/1½
,,	20×10, ,,	24/7½
,,	18¾×14, ,,	18/4½

Terneplates 28×20, 35/9 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered £19/0 to £20/0
Rolled Ord. £16/0/0 to£16/10/0
Nail rods £16 5 0 to £16 15 0
Keg. steel nom. £33 to £35
Faggot steel nom. £22 to £25
Blooms, according to quality £9 to £12
Pig-iron £6 15 0 to £7 0 0 all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas ..	60%	.. 50%
Water ..	55%	.. 45%
Steam ..	50%	.. 40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.	
Jan. 28	58	0	0	dec. 7/6
„ 29	58	0	0	No change
Feb. 1	58	10	0	inc. 10/–
„ 2	58	12	6	„ 2/6
„ 3	59	5	0	„ 12/6

Electrolytic Copper.

	£	s.	d.	
Jan. 28	64	10	0	dec. 10/–
„ 29	64	15	0	inc. 5/–
Feb. 1	65	0	0	„ 5/–
„ 2	65	5	0	„ 5/–
„ 3	65	15	0	„ 10/–

Standard Tin (Cash).

	£	s.	d.	
Jan. 28	275	5	0	dec. 15/–
„ 29	274	0	0	„ 25/–
Feb. 1	279	12	6	inc. 112/6
„ 2	279	5	0	dec. 7/6
„ 3	279	10	0	inc. 5/–

Tin (English ingots).

	£	s.	d.	
Jan. 28	274	0	0	dec. 5/–
„ 29	273	0	0	„ 20/–
Feb. 1	278	5	0	inc 105/–
„ 2	278	0	0	dec. 5/–
„ 3	277	10	0	„ 10/–

Zinc Sheets (English).

	£	s.	d.	
Jan. 28	46	0	0	No change
„ 29	46	0	0	„ „
Feb. 1	46	0	0	„ „
„ 2	45	0	0	dec. 20/–
„ 3	45	0	0	No change

Spelter (ordinary).

	£	s.	d.	
Jan. 28	36	12	6	dec. 5/–
„ 29	36	17	6	inc. 5/–
Feb. 1	37	1	3	„ 3/9
„ 2	37	2	6	„ 1/3
„ 3	36	16	3	dec. 6/3

Lead (English).

	£	s.	d.	
Jan. 28	35	5	0	No change
„ 29	35	10	0	inc. 5/–
Feb. 1	35	15	0	„ 5/–
„ 2	35	15	0	No change
„ 3	35	10	0	dec. 5/–

AVERAGE MONTHLY PRICES OF CLEVELAND No. 3 PIG-IRON.

Year.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d
1887	37 5	35 10	34 4	34 4	34 1	34 10	34 4	34 5	33 9	31 10	31 8	33 6	34 2
1888	32 2	31 1	31 5	31 9	30 11	31 5	32 4	33 5	34 8	34 2	33 11	33 10	32 7
1889	33 8	35 0	37 5	38 9	38 6	37 10	40 1	43 4	44 1	51 5	64 7	61 1	43 10
1890	60 3	53 1	51 0	47 4	42 2	41 5	43 2	45 7	47 9	47 10	47 4	43 1	47 6
1891	42 1	41 10	39 9	38 7	40 9	41 0	40 8	39 8	40 4	39 11	38 8	38 1	40 1
1892	37 7	35 7	36 10	37 10	39 2	40 11	39 11	39 10	40 0	38 6	37 6	37 4	38 5
1893	36 0	34 3	34 4	34 2	33 10	34 8	35 3	35 5	34 8	34 8	34 7	35 9	34 10
1894	35 8	35 11	36 1	36 1	35 5	35 5	35 5	35 11	36 6	35 8	35 8	35 1	35 9
1895	34 7	34 4	34 4	34 8	35 6	35 2	36 1	37 1	38 10	38 6	37 11	37 6	36 3
1896	37 3	38 4	38 7	38 1	37 4	37 4	36 11	36 11	37 11	39 2	40 5	40 5	38 3
1897	41 2	40 4	40 5	39 2	39 7	40 9	39 6	40 5	41 7	42 5	41 5	40 4	40 7
1898	40 9	40 8	40 6	40 0	40 7	39 11	40 4	41 11	43 0	44 11	49 1	44 3	42 0
1899	46 10	47 11	47 9	49 10	55 11	62 10	71 6	65 9	67 7	68 8	70 0	66 9	60 5
1900	67 10	68 10	73 10	76 2	74 2	68 6	69 3	71 4	70 9	67 8	63 6	53 6	68 9
1901	48 0	46 6	45 8	45 5	45 10	44 7	44 6	45 3	45 3	45 3	43 6	43 1	45 3
1902	43 11	46 7	46 9	47 11	48 10	49 7	50 9	52 1	53 6	52 9	50 9	47 11	49 3
1903	47 3	48 9	51 10	49 0	46 1	46 2	46 7	46 8	45 7	43 6	42 10	41 11	46 4
1904	42 3	42 7	43 3	44 7	44 0	42 10	42 9	43 3	43 1	43 9	46 1	48 7	43 11
1905	48 11	48 0	49 6	50 1	51 5	45 6	45 9	47 5	48 8	52 11	52 9	53 3	49 6
1906	53 9	50 1	48 1	48 8	50 2	50 3	50 6	53 0	54 6	56 8	58 6	62 4	53 0
1907	60 4	56 6	54 10	56 0	61 1	58 1	57 8	57 8	55 7	54 8	50 8	50 0	56 2
1908	48 5	49 3	51 7	51 10	51 6	51 2	50 0	51 4	52 0	49 8	49 4	48 11	50 8
1909	48 10	48 1	46 9	47 9	48 4	48 9	48 6	50 5	51 3	51 11	51 2	50 7	49 4
1910	51 10	51 3½	51 7½	50 10	49 10	49 2	48 10	49 8½	49 3½	49 7½	49 6½	49 10	50 4
1911	49 11½	49 2½	48 5	46 11	46 4	46 6	46 11½	47 4	47 0	46 7	4 4	48 1	47 7
1912	50 0	49 5½	51 1½	53 7½	54 4	55 1	57 5½	64 6½	61 7½	66 8½	67 8	68 0	58 5½
1913	66 11½	63 8½	64 8	67 1½	66 3	56 9½	56 3½	55 8	55 4	53 0	50 1	50 4	58 10
1914	50 11	51 5½	51 0½	51 4½	51 6	51 6½	51 5	52 3	51 5	50 1	50 3	53 0	51 4½
1915	55 7	56 6	61 0	66 7	65 2	66 10	65 4	66 0½	65 3	65 11	69 10½	75 7½	65 7½
1916	80 2	91 6	87 4½	86 10	82 6	82 6	87 6	87 6	87 6	87 6	87 6	87 6	85 10
1917	87 6	87 6	87 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	92 6	95 0	91 3
1918	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0	95 0
1919	95 0	95 0	95 0	95 0	152 6	160 0	160 0	160 0	160 0	160 0	160 0	160 0	137 8
1920	175 0	175 0	187 6	200 0	208 0	217 6	217 6	221 0	225 0	225 0	225 0	225 0	209 3
1921	222 6	195 0	150 0	126 0	120 0	120 0	120 0	136 3	127 0	120 0	110 0	100 0	137 4
1922	92 6	90 0	90 0	90 0	90 0	90 0	89 0	87 3	92 6	92 6	92 6	91 3½	90 7½
1923	94 6	108 9	125 6	129 4½	128 5	136 0	128 1½	121 11	97 0	100 0	100 0	100 0	110 6½
1924	99 10	97 3½	91 9	93 9	91 9	89 10½	87 9	85 0	82 5½	80 2½	81 9	81 9	88 7½
1925	80 4½	78 10½	78 0	78 3½	76 0	73 10½	71 7½	69 10½	68 1½	66 7½	66 0	66 10½	72 10½
1926	69 4½	—	—	—	—	—	—	—	—	—	—	—	—

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